



**US Army Corps  
of Engineers**  
St. Paul District

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**DESIGN MEMORANDUM NO.2  
FLOOD CONTROL PROJECT**

**MINNESOTA RIVER**

**STAGE 4**

**CHASKA, MINNESOTA**

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**MARCH 1991**

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1. REPORT DATE (DD-MM-YYYY) 3/91		2. REPORT TYPE Final		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Minnesota River stage 4 Chaska, Minnesota: design memorandum no. 2, flood control project.				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
				5d. PROJECT NUMBER	
6. AUTHOR(S)				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Corps of Engineers, St. Paul 190 5th St. E. St. Paul, MN 55101				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution					
13. SUPPLEMENTARY NOTES Includes supplement no. 1, fish and wildlife facilities.					
14. ABSTRACT This design memorandum presents the design and discussion of planning for stage 4 which consists of a levee that protects Chaska from flooding of the Minnesota River. Work includes upgrading existing levee, construction of new levee, a pumping station, outlets with gateways, interceptor pipe with manholes and inlets, relief wells and sanitary sewer with lift station. Also included is a recreational trail.					
15. SUBJECT TERMS Flood control Minnesota River					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)
Unclassified	Unclassified	Unclassified			





## DEPARTMENT OF THE ARMY

ST. PAUL DISTRICT, CORPS OF ENGINEERS  
1421 U.S. POST OFFICE & CUSTOM HOUSE  
ST. PAUL, MINNESOTA 55101-9808

REPLY TO  
ATTENTION OF

CENCS-ED-M (1110)

24 APR 1961


MEMORANDUM FOR Commander, North Central Division, ATTN: CENCD-PE-ED, 536  
South Clark Street, Chicago, Illinois 60605-1592

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota, Design  
Memorandum No. 2, Stage 4, Minnesota River

1. Subject report is submitted in accordance with EC 1110-2-265 for your review and approval.
2. This design memorandum presents the design improvements for construction of the levee modifications, pump station, and related structures as well as recreational features for the Minnesota River at Chaska, Minnesota.

FOR THE COMMANDER:

Encl (16 cys)  
Chaska Stage 4 DM

  
ROGER L. BALDWIN  
Colonel, Corps of Engineers  
Commanding

FLOOD CONTROL  
MINNESOTA RIVER AT  
CHASKA, MINNESOTA

DESIGN MEMORANDUM NO. 2

MINNESOTA RIVER

DESIGN MEMORANDUM SCHEDULE

<u>Number</u>	<u>Scheduled Completion</u>	<u>Submitted NCD</u>	<u>Submitted OCE</u>	<u>Approved</u>
General	Mar 84	6 Mar 84	May 84	Jul 84
1. Chaska Creek (Stage 2)	Jul 84	Dec 84	Feb 85	Aug 85
2. Minnesota River (Stage 4)	Mar 91(1)			
3. East Creek (Stage 3)	Feb 92			

(1) The Fish and Wildlife Mitigation Features are not included. These will be provided separately.

## EXECUTIVE SUMMARY

The Chaska, Minnesota Flood Control project was authorized for construction by Section 102 of the 1976 Water Resources Development Act, Public Law 94-587. Chaska is on the Minnesota River in Carver County in south-central Minnesota about 20 miles southwest of Minneapolis-St. Paul.

The flood control project provides flood protection to Chaska by diverting both Chaska and East Creeks and by providing a levee that protects against flooding by the Minnesota River. The creek diversions provide Standard Project Flood protection and the levee provides one-percent chance flood protection. Pertinent data is on the following page.

The total estimated project cost is \$38,700,000. Federal costs are estimated at \$29,000,000; non-Federal costs are estimated at \$9,700,000. The estimated cost for Stage 4, Minnesota River is \$10,955,000. Federal cost for Stage 4 are estimated at \$8,243,000; non-Federal costs are estimated at \$2,712,000.

The Local Cooperation Agreement was executed in September 1988. The Stage 1 construction contract was awarded in September 1988. The Stage 2 construction contract was awarded in August 1989. Stages 3 and 4 are scheduled for a construction contract award in October 1993 and January 1993 respectively.

This Design Memorandum presents the recommended design for Stage 4, Minnesota River levees. The design includes 4,200 feet of improved levee, 2,800 feet of new levee, one 18,000 gpm pump station, two outlets with gatewells, interceptor pipe with manholes and inlets, relief wells, and sanitary sewer with lift station. Also included is a recreation trail.

## PERTINENT DATA

Project Document - House Document 94-644, 94th Congress, 2nd Session.

Project Authorization - 1976 Water Resources Development Act (Public Law 94-587).

Project Purpose - Flood Control.

Location - The project is located on the Minnesota River in Carver County and Chaska, Minnesota, and includes both Chaska and East Creeks, which are tributaries of the Minnesota River.

### Hydrology and Hydraulics

#### Watershed Drainage Area

Chaska Creek Diversion Inlet	14.9 Square Miles
East Creek Diversion Inlet	10.1 Square Miles
Minnesota River	16,600 Square Miles

#### Design Flood Event

Chaska Creek	Standard Project Flood
East Creek	Standard Project Flood
Minnesota River	One-percent Chance Flood

#### Design Flows

Chaska Creek Diversion	6,040 cfs
East Creek Diversion	5,500 cfs
Minnesota River	168,000 cfs

### Principal Items of Work

#### Diversion Channel

Stage 2	5,800 LF
Stage 3	6,000 LF

#### Levee Improvement

Stage 2	2,100 LF
Stage 4	4,200 LF

New Levee, Stage 4	2,800 LF
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Drop Structures, Stage 3	2
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Pumping Station, Stage 4	1
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#### Bridges

Stage 2	4
Stage 3	4

### Economics

Federal first cost	\$29,000,000
Non-Federal first cost	9,700,000
Total first cost	38,700,000
Average annual operation & maintenance cost	42,000
Total average annual cost	3,149,900
Average annual benefits	2,260,000
Benefit-cost ratio	0.72

FLOOD CONTROL  
MINNESOTA RIVER AT CHASKA, MINNESOTA

DESIGN MEMORANDUM NO. 2, STAGE 4

FISH AND WILDLIFE FACILITIES

SUPPLEMENT NO. 1

Department of the Army  
St. Paul District, Corps of Engineers

May 1993

FLOOD CONTROL  
MINNESOTA RIVER AT CHASKA, MINNESOTA

DESIGN MEMORANDUM NO. 2, STAGE 4

FISH AND WILDLIFE FACILITIES

SUPPLEMENT NO. 1

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FLOOD CONTROL  
MINNESOTA RIVER AT CHASKA, MINNESOTA

DESIGN MEMORANDUM NO. 2, STAGE 4

FISH AND WILDLIFE FACILITIES

SUPPLEMENT NO. 1

INTRODUCTION

1. This supplement explains the design and gives details of the Fish and Wildlife facilities that are to be constructed as a mitigation feature for the Chaska Flood Control project. These facilities will be operated by the U.S. Fish and Wildlife Service (FWS).

2. Construction of the flood control features for the Minnesota River at Chaska, Minnesota Flood Control project will result in the loss of 40 acres of terrestrial habitat, excluding cropland and urban grasslands. A detailed evaluation of the impacts and the mitigation plans considered is presented in the references cited. The authorized mitigation plan for the project consists of two primary features: (1) construction of a 19 acre moist soil unit on the Chaska Lake Unit of the Minnesota Valley National Wildlife Refuge, and; (2) the construction of a water control structure on Chaska Lake. This supplement presents the design of these mitigation features.

REFERENCES

3. Limited Reevaluation Report and Final Supplement to the Final Environmental Impact Statement for Flood Control and Related Purposes, Minnesota River at Chaska, Minnesota, August 1982.

4. General Design Memorandum and Draft Supplement II to the Final Environmental Impact Statement, Minnesota River at Chaska, Minnesota, Flood Control Project, Revised August 1984.

5. Final Supplement II to the Final Environmental Impact Statement, Minnesota River at Chaska, Minnesota, Flood Control Project, February 1985.



## MOIST SOIL UNIT

### GENERAL

6. The completed moist soil unit will be a shallow, man-made wetland which will be managed to provide feeding habitat for songbirds, wading birds and waterfowl. This feature will be created by diking a site that is currently in cropland. The system will consist of two cells that can be flooded to a depth of about two feet and managed independently. The General Plan for the moist soil unit is shown on Sheet 5.

7. The general design of the moist soil unit consists of three-foot high dikes with a 12 foot top width. The top of the dikes will have a gravel surface that can be driven on with maintenance and operational equipment. Selected areas of the dikes will be covered with rock to ensure dike integrity during flood events on the Minnesota River. Three stoplog control structures, one at the outlet for each unit and one between the two management cells, will allow for independent water management of the management cells.

8. Water supply for this feature is Chaska Lake. A concrete pad will be installed on the west side of the unit adjacent to Chaska Lake. The FWS would use a portable pump to pump water from Chaska Lake to flood the cells.

### HYDRAULICS

9. Three 24" corrugated metal pipe (cmp) culverts are required to drain the moist soil units. Two culverts, about 90'-3" and 95'-3" long with control structures, will be located on the northeast side of the unit to drain each cell toward the Minnesota River and permit backflow from the river into the cells during the rise and fall of the river. A 37'-5" culvert will also be provided near the north end of the interior dike to permit the regulation of flow from one cell to the other. Elevation-discharge-head curves for the proposed culverts are presented on Plate S-1. A trapezoidal earth ditch, about 185' long, with a base width of 15 feet and 1 on 3 side slopes, is required downstream from the 90'-3" and 95'-3" culverts. The ditch will have a bottom elevation of about 703.10 at the upstream end and slope downstream on a grade of about 1.6 percent. A stoplog control structure is to be constructed at the inlet to each culvert to permit the regulation of pond levels.

10. Riprap is recommended at each end of the three culverts to prevent possible erosion and/or scouring. The required riprap blanket at each end of the 90'-3" and 95'-3" culverts will be 12" thick, extend about 10' upstream and downstream from each culvert opening, and extend to a height equal to the top of the ditch or crown of the culverts. The required riprap blanket at each end of the 37'-5" culvert is to be 12" thick and cover a rectangular area

beginning about 10' from the end of the culvert, extend 5' to each side of the culvert centerline, and extend up the berm adjacent to the culvert to a height equal to the top of the annular fill surrounding the culvert. The required riprap gradation is as follows:

Percent Lighter By Weight	Limits of 165 Pound Stone Weight In Pounds	
	Maximum	Minimum
100	86	35
50	26	17
15	13	5

11. The proposed plan is to fill the moist soil units to elevation 705.5 during the spring and fall months, and empty the units each summer. When the units are to be emptied and bulkheads are removed, outflow through the culverts with an initial interior pond level of 705.5 will be about 11 cfs through one pipe or about 22 cfs, if both pipes are opened, resulting in an exit velocity of about 3.5 feet per second at the outlet end of each pipe. With a discharge rate of about 11 cfs, the estimated depth and average velocity in the ditch will become about 0.5 feet and 1.5 feet per second, respectively. With a discharge rate of about 22 cfs, the estimated depth and average velocity in the ditch will become about 0.7 feet and 2.1 feet per second, respectively. The base width for the proposed ditch is required to provide proper maintenance and permit the deposition of sediment without obstructing the outflow from the upstream culverts. Elevation-area-storage relationships for each of the moist soil units are presented on Plate S-2. As indicated on Plate S-3, the required time to empty one of the units using only one of the outlet pipes (or both units using both outlets simultaneously) from a starting elevation 705.5 will be about 45 hours. It would take about 90 hours to empty both units using only one outlet.

12. The design of the gravity outlets and the riprap are based on the criteria presented in Appendix A of Design Memorandum No. 2, paragraph A-49 (page A-12), references h, i, and j; assuming a Manning's roughness coefficient of 0.024 for corrugated metal pipe, an entrance coefficient of 0.5 and a stone weight of 165 pounds. The design of the earth ditch is based on criteria presented in EM 1110-2-1601 (subparagraph A-49c, above reference), assuming a Manning's coefficient of 0.08 for depths less than 0.5 feet, 0.06 for depths from 0.05 to 1.5 feet, and 0.04 for depths greater than 1.5 feet.

13. Although it can be shown that no riprap protection is required on the dikes, the FWS requests that about 1,200 linear feet of dike on the north side of the units be protected with rock protection. Their experience is that the downstream portion of the moist soil unit will erode during receding river levels.

## GEOTECHNICAL

14. The site is located on the flat floodplain just south of Chaska's business district. Ground surface elevations range from approximately 702 to 708 (1929 Adjusted). The site is bounded on the west by Chaska Lake, on the north by Chaska Creek, and on the east and south by the Minnesota River. The soil stratigraphy and top of bedrock was defined by borings while the bedrock stratigraphy and aquifer characteristics were inferred from published U.S. Geological Survey data and local water records. The subsurface consists of alluvial clays, silts and sands to elevation 530, (soil thickness approximately 175 feet). The underlying bedrock, from top to bottom consists of; dolomitic siltstone of the St. Lawrence Formation, interbedded sandstone and shale of the Franconia Formation, interbedded sandstone and shale of Dresbach Formation, and the Hinkley Sandstone. The alluvial sand is a local aquifer capable of moderate to high yields. The Franconia and upper beds of the Dresbach Formation comprise a regional aquifer capable of moderate yields, while the Hinkley Sandstone and the lower beds of the Dresbach Formation comprise a regional aquifer capable of high yields.

15. A boring was taken near the site in 1983 in the early planning for the Chaska Creek portion of the Chaska Flood Control project. Three borings were taken in 1989 to determine if the upper soil layer was suitable for constructing a moist soil unit. One deep boring was taken in 1991 to determine if an adequate supply of water could be obtained by installing a well in the underlying sand aquifer. Additional shallow borings were taken in 1991 to determine the continuity and thickness of the upper layer of impervious soil. The boring locations are shown on Sheet 5 and the boring logs are shown on Sheet 2 through Sheet 4. Atterberg limits and gradation tests performed on samples from the 1983 and 1989 borings are shown on figures 1 and 2.

16. The site has a surface layer of clay that appears to be at least four feet thick. Underlying this is a fairly thick layer of interbedded clays, silts, and sands which extends to approximately elevation 620. Below this is a fairly thick layer of sands and silty sands which extends to the bedrock at elevation 530. This layer of sands contains some clay seams.

17. The dikes will have either 1V to 3H side slopes if covered with riprap or surge rock protection or 1V to 4H side slopes if grass covered. The dikes will have a 12 foot top width and gravel surface. Surge rock, located and sized as directed by the FWS, will be placed on selected portions of the dikes. The gradation and thickness of the surge rock is shown in Table A. Areas of the unit that do not have gravel surface, surge rock or riprap will receive 4 inches of topsoil and be seeded. Outlet control structures placed in the dikes will be backfilled with impervious material.

TABLE A

## Surge Rock

type	thickness	percent passing	sieve size
B	8 or 12	100 0	8" 4"
A	4 or 6	100 0	3" #200

18. The FWS requested that the water supply be capable of filling the cells in 20 days. The flow rate required was calculated based on an early plan of the Moist Soil Unit and assuming an average water depth of 1.75 feet. Evaporation losses were based on information contained in the "Hydrology Guide for Minnesota" published in 1955 by the Soil Conservation Service. Seepage losses were calculated assuming the clay layer at the bottom of the cells has a thickness of two to three feet with some of that layer disturbed by plowing. The calculated flow rate was increased 25 percent for a safety factor to obtain a flow rate of 600 gallons per minute.

## STRUCTURAL

19. Structural features consist of three water control structures. A water control structure consists of a half riser stoplog closure at the inlet and a pipe with a flared end section at the outlet. The stoplog closure will control the water surface at each cell.

20. The cmp used for the half riser and outlet pipe shall be circular, galvanized and bituminous coated with 2-2/3 inches x 1/2 inch corrugations. The half rise is made from 48 inch diameter 12 gauge cmp. Half the pipe is used for the stoplog closure above grade. The full diameter of pipe below grade is filled with concrete for the base. The concrete also acts as weight to resist flotation of the riser. The outlet pipe shall be 24 inch diameter 16 gauge cmp. Connecting bands at pipe joints shall be watertight and flexible. The flared end section and connection bands shall be fabricated from the same material as the outlet pipe.

21. The steel angles used in the half riser for stoplog grooves and bracing shall have welded connections. The entire riser section shall be galvanized after fabrication.

22. Stoplogs shall be made of any available No. 1 structural grade rough sawn lumber. The stoplogs shall be cut to the dimensions shown on the drawings and treated with preservative. The size of each stoplog will be dependent on availability and top of stoplog

elevation required, but must have a minimum net width of 3-1/2 inches. Lift rods for the stoplogs shall be 1/2 inch diameter and 7 inches long. A locking bar to prevent stoplog removal by unauthorized persons shall be provided on each stoplog closure.

23. Each control structure will have a platform to provide access to the stoplog closure from the dike. The platforms will be supported on the outlet pipe and half riser stoplog closure. The post spacing can be adjusted to provide a better approach from the dike or to accommodate pipe lengths. The spacing shall not exceed 8 feet.

24. The angles used for the platform shall be ASTM A36 steel. The transverse frames shall have welded connections to provide lateral support. Truss bars will provide lateral support in longitudinal direction. The platform members, frames and bolts shall be galvanized after fabrication.

25. The structural features associated with the water supply from Chaska Lake are a concrete pad in the ditch for the portable pump and a concrete wall supporting the crane which will lift the pump onto the pad. The concrete shall have a minimum 28-day compressive strength of 4,000 psi and reinforcement shall be ASTM Grade 60.

26. The crane to be provided will be a 500 pound capacity jib crane specifically designed for lifting pumps. All anchors and fasteners will be stainless steel. The crane will be designed to sit outdoors for extended periods of time. A stainless steel cable will provide 30 feet of lift and loads shall be raised and lowered with a hand winch. The boom shall rotate 360 degrees and fold down for storage.

#### MECHANICAL

27. The moist soil unit will be filled using water pumped from Chaska Lake. The hydraulic pump system will include a diesel power unit, submersible pump and discharge tubing. The diesel power unit will be mounted on a trailer and parked on top of the dike as shown on Sheet 9.

28. Operation. Setup shall require one person about four hours. Spring and fall the diesel power unit will be towed to the moist soil unit and parked on the dike. The size and weight of the diesel power unit allows towing with a 1/2 ton pickup truck. The pump and tubing can be transferred in the pickup box. The diesel power unit shall be leveled using the trailer's adjustable legs. The trailer tongue can be removed for security. The pump weight is 67 pounds. Discharge tubing shall be connected to the pump and placed over the dike to the moist soil unit. Hydraulic hoses need to be connected from the diesel power unit to the pump. The hydraulic fluid reservoir, motor oil, radiator and diesel fuel tank

will need to be checked and filled before starting the motor. Operating costs are: \$1.00 per gallon diesel fuel \* 26 gallons per day \* 20 days \* 2 seasons = \$1,440.00 per year.

29. Maintenance. Each day of operation the diesel power unit fluid levels should be checked and filled.

30. Equipment. The diesel power unit (figures 3 and 4) will include a 22 horsepower, water cooled diesel engine; hydraulic pump, hydraulic reservoir, 50 feet of pressure and return hydraulic hoses with quick disconnect couplings; control panel with automatic safety shutdown for low hydraulic oil level, high hydraulic oil temperature, low engine oil pressure and high engine temperature, tachometer, ammeter, throttle control; high speed single axle trailer with adjustable stabilizing legs and removable tongue; 12V battery; and 160 gallon self contained fuel tank. To deter vandalism, the entire unit will be covered with wire mesh and a duckbill anchoring system will be installed. Pump selection will be a submersible open type trash pump (figures 5 and 6) designed to pump water containing solids such as mud, weeds and sticks. The pump capacity will be 710 gallons per minute maximum flow rate with 20 feet of head, assuming 10 feet of friction losses. Friction losses include 60 feet of 4 inch discharge tubing, pump column discharge losses, and fitting losses. The bearing housing shall be high grade cast steel. The bearings and seals will be lubricated by low pressure hydraulic oil eliminating the need to grease the bearings each day. The pump has the ability to run dry without damage. The discharge tubing shall be Butyl Nylon, 4 inch diameter and 60 feet long.

#### CULTURAL

31. In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, the National Register of Historic Places has been consulted. According to the Federal Register, as of May 22, 1991, there are no sites listed on or eligible for the National Register that will be affected by construction of the proposed moist soil unit. The moist soil unit was surveyed for cultural resources in April 1991. No cultural resources were encountered. The results of this survey are being coordinated with the Minnesota State Historic Preservation Office.

#### CHASKA LAKE WATER CONTROL STRUCTURE

#### GENERAL

32. The water control structure on Chaska Lake will enable the FWS to manipulate water levels on Chaska Lake. This will allow for various desired management objectives such as to enhance the growth

of submerged aquatic vegetation or to provide the optimum ratio of emergent vegetation to open water.

33. The control structure is designed so that Chaska Lake can be completely drained by gravity during normal and low flows on the Minnesota River. The STAGE-DURATION CURVE plate A-10 in Appendix A of Design Memorandum No. 2, can be used to determine gravity drainage limitations.

34. Dredging in Chaska Lake would be required to ensure that the proposed outlet for Chaska Lake Ditch and the Moist Soil Unit Inlet Ditch would operate effectively. The dredged channel for the Chaska Lake Ditch would be about 800 feet long with an average dredge cut of about 1 foot. The dredge cut for the Inlet Ditch would be similar in depth and would run for about 100 feet. A total of about 300 cubic yards of material would be dredged.

35. The sediments in Chaska Lake are primarily silt and silt clay. Land use around Chaska Lake has historically been undisturbed woodlands on the north and west sides of the lake, and moderate agricultural use on the south and east sides of the lake, with these areas being used intermittently for hayland and row crops.

36. It is anticipated that dredging would be done using a portable hydraulic dredge. The constructed moist soil unit would be utilized as the containment area for this operation. Dredged material would be used as topsoil for the moist soil unit to provide a seed bank for wetland plant species.

#### HYDRAULICS

37. The proposed outlet from Chaska Lake to Chaska Creek will consist of a 780' trapezoidal earth ditch, a 63'-1", 24" cmp culvert with control structure and scourhole, and a 95' trapezoidal earth ditch. The control structure is to consist of a 48" half cmp riser at the upstream end of the culvert with stoplog slots, and is required to permit the lake to be drained. A riprapped scourhole, 4' wide, 6' long and one foot deep with 1 on 3 side slopes, is required at the downstream end of the culvert to dissipate the outflow energy from the culvert. The trapezoidal ditches will be constructed with a 4' base width, 1 on 3 side slopes, and a 0.3 percent slope. Based on a 0.3 percent slope, the recommended invert elevations for the proposed culvert are 697.71 at the upstream end and 697.49 at the downstream end. The channel bottom for the upstream ditch will drop from about elevation 700.0 at the lake outlet to about 697.2 at the entrance to the culvert. (It is recommended that the last 10' of ditch adjacent to the culvert be constructed with a bottom elevation of about 697.7 at the upstream end and 697.2 at the entrance to the culvert to prevent the transportation of sediment and riprap into the culvert.) The channel bottom for the downstream ditch will drop from about 697.5

at the downstream end of the scourhole to about 697.2 at Chaska Creek. Riprap, 12" thick, is required about 10' upstream of the culvert and 24' downstream of the culvert and should extend up the sides of the ditch, scourhole, and culvert fill to the top of the ditch or an elevation equal to the crown of the culvert, whichever is less.

38. The proposed plan is to keep the stoplogs in place, except when the lake is to be drained. Based on a design lake level of about 704.3, the design outflow through the culvert will be about 27.5 cfs, which will result in an exit velocity from the culvert of about 8.8 feet per second. To prevent the possibility of scour or erosion at the entrance and exit from the culvert, riprap of the same gradation and thickness as presented in paragraph 10 above is recommended. Elevation-discharge rating curves for the Chaska Lake outlet structures are presented on Plate S-4. Based on a discharge of about 27.5 cfs, the estimated maximum water surface elevations at the entrance to the upstream ditch, upstream end of the culvert, and downstream end of the culvert will be about 704.3, 704.3 and 699.2, respectively. An elevation-storage curve for Chaska Lake is presented on Plate S-2. As indicated on Plate S-3, the estimated time required to drain the lake will be about 9 days. Criteria used to design the culvert, ditches and riprap cover are the same as presented in paragraph 12.

#### STRUCTURAL

39. The structural feature of the Chaska Lake Water Control Structure is one water control structure. The new control structure will replace an existing 18 inch cmp. The water control structure consists of a half riser stoplog closure at the inlet and a pipe with a flared end section at the outlet. The stoplog closure will control the water surface in the Chaska Lake ditch.

40. The description of the Chaska Lake Water Control Structure will be the same as described for the Moist Soil Unit Water Control Structures. The only difference is there will be handrails provided on the platform due to the height of the platform above the ground.

#### COST ESTIMATE

41. The M-CACES cost estimate was completed by work analysis. It is included as Attachment 1. The estimated construction cost with contingency is \$350,000.00.



#### OPERATION AND MAINTENANCE

42. The FWS will operate and maintain the moist soil unit and water control facilities.

#### REAL ESTATE

43. The mitigation facilities proposed will be constructed on FWS refuge land.

#### COORDINATION

44. The design of the moist soil unit and water control facilities have been coordinated with the FWS and City of Chaska. See attached letter from the FWS.

#### SCHEDULE FOR DESIGN AND CONSTRUCTION

45. Plans and Specifications are to be completed in September 1993 so that a construction contract can be awarded in December 1993. Construction would be completed by 1 August 1994.

Project:						Chaska Flood Control							Range:		Surf. Elev.		Boring No.: 83-52M through 83-57M Bottom Of Hole:		MRD Lab. No.: 84734		
Station:																					
Sample No	Depth To Bottom Of Sample	Moisture (%)	Plasticity (At Limits)		Grading (Cumulative Percents Finer) U.S. Standard Sieve Sizes					Gradation Curve Analysis						Classification <i>Tech MEMO 3-357, May 67</i>	Remarks				
			L.L.	P.I.	Hyd Analysis		Fines			D <sub>50</sub> (mm)	D <sub>60</sub> (mm)	D <sub>10</sub> (mm)	C <sub>u</sub>	C <sub>c</sub>							
					#200	#40	#10	#4	3/8"						1/2"			3/4"			
Hole 83-52H 3	8.6																				
7	16.2					7	9	15	48	88	100					0.98	0.58	0.19	5.2	1.8	
12	36.5	21.4	35	15		5	30	92	100							0.28	0.18	0.088	3.2	1.1	
13	41.5	21.7	NP	NP		47	96	100												20	
Hole 83-53H 2	3.5	35.4	45	24																	21
4	9.5	32.3	39	22																	17
6	14.5	32.5	35	13																	22
11	29.5	91.6	210	171																	Organic 39
Hole 83-54H 1	1.5	7.5	31	13																	18
3	11.5					18	69	99	100												
5	15.5					7	21	71	99	98	100					0.35	0.22	0.090	3.9	1.5	
Hole 83-55H 2	2.0																				
4	4.5					38	52	68	77	84	90	93	97	100							
5	14.5					43	84	90	93	95	97	100									
7	22.8					18	25	44	60	70	78	86	92	100							
						4	9	33	52	62	73	83	88	100		1.5	0.42	0.18	8.3	0.65	
Hole 83-56H 2	7.5	29.0	34	16																	18
3	12.5					3	6	13	21	31	49	77	88	100		6.4	1.8	0.30	2.13	1.8	
4	14.5					5	14	58	82	95	100					0.43	0.24	0.14	3.1	0.96	
Hole 83-57H 4	14.5																				
5	19.0					5	7	14	21	30	42	54	64	100		14.0	1.9	0.27	51.2	0.96	
						6	9	20	30	43	60	73	83	100		5.0	0.90	0.19	25.3	0.85	

WARD FORM 16 EDITION OF MAY 70 IS OBSOLETE

depth	L.L.	P.I.	P.L.	Wc	Classification	Type of test
17'-19'	81	44	37	83%	MH	Q & Consolidation
26'-28'	207	133	74	74%	OH	Q & Consolidation
42'-44'	26	10	16	30%	CL	Q
50'-51'	31	16	15	24%	CL	Q

PROJECT:	Chaste Flood Control Project - East Creek	WORKING:	89-127a, 89-128a and 89-129a	END LAB NO.	99/137
----------	---	----------	------------------------------	-------------	--------

STATION:		RANGE:		SURF. ELEV.:		DEPTH TO WATER TABLE:		BOTTOM OF HOLE:	
DEPTH		PLASTICITY		GRADING (CONCLUSIVE PERCENTS FINER)		GRADING (CONCLUSIVE PERCENTS FINER)		CLASSIFICATION	
SAMP. BOTTOM		MOIST. (H)		HYD. ANALYSIS		U.S. STANDARD SIEVE SIZES		REMARKS	
NO. TOP SAMP.		URE (H)		FINES		SANDS			
		LL		PI		60		Cc	
		PL		.005		200		Cu	
<p>Base : 89-127:</p> <p>1 : 4.5 : 18.9 : 37 : 20</p> <p>2 : 9.5 :</p> <p>4 : 16.0 :</p>									
<p>Base : 89-128:</p> <p>1 : 3.2 : 22.8 : 67 : 39</p> <p>2 : 5.0 : 30.5 : 37 : 22</p> <p>3 : 5.5 :</p> <p>5 : 14.5 :</p>									
<p>Base : 89-129:</p> <p>1 : 0.5 : 13.6 : 50 : 29</p> <p>2 : 4.5 : 0.6 : 26 : 12</p>									

TABLE 1



**DEWATERING  
DESIGNERS  
PUMPS**

# POWER UNITS

## HYDRAULIC POWER UNITS

Back in the 17th century Blaise Pascal discovered that a fluid under pressure could be used to transmit power.

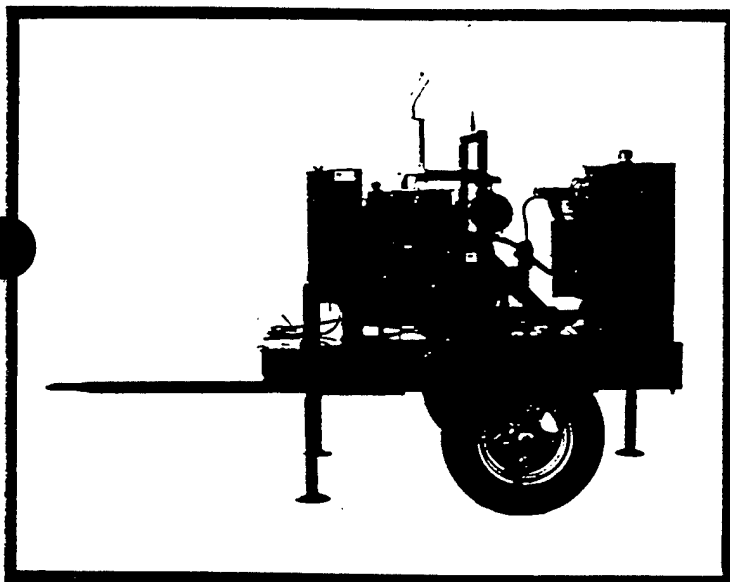
Hydraulics is transmitting power through a fluid, in a fluid conductor to do work. This is the most unique method of transmitting energy to do work. It is less cumbersome than straight shaft mechanical transmission. It has virtually infinite speed control and is more precise in controlling energy.

By use of the hydraulic motors compactness, light weight, and the flexibility of the hydraulic hoses, permits the power source to be remotely located in a safe and accessible area. It also provides a means of varying the speed of the impeller by controlling the flow of the oil to the pump head.

D & D uses this versatile, horsepower dense, form of power transmission, to drive their pumps. By utilization of variable displacement or multi-section pumps allows D & D power units to drive a wide range of pump heads or multiple pump heads.

With the availability of additional options the power units can drive generators, air compressors and hydraulic tools, making D & D power units a stand alone power source.

Power units are available in Diesel or Electric on trailer or skid mounts and may be custom built to your needs.



## HYDRAULIC POWER UNIT SPECIFICATIONS DIESEL

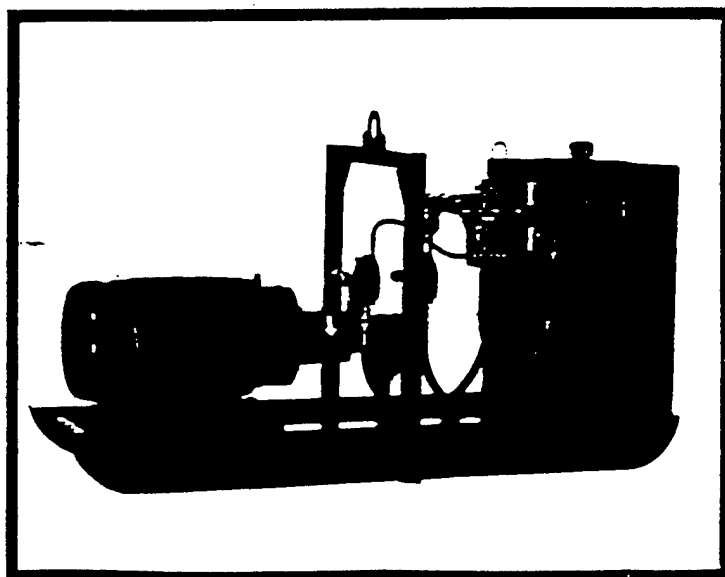
Power Unit Model	Recommended Pump Heads	H.P.	Hose Size	Volume Cu. Ft./Cu. Mtr.	Weight Lbs./Kg.
50/60*	3LT, 4LT	16	.50" & .50"	19.5/.54	250/114
75	4LT, 8AX	19	.50" & .50"	21/.58	700/318
100	4T, 10AX	22	.50" & .75"	58/1.6	1300/590
250	4S, 6T, 12AX, 14AX	40	.75" & 1.0"	165/4.7	1625/737
400	6S, 8T, 16AX	65	1.0" & 1.25"	235/6.7	2750/12147
500T*	6S, 8T, 20AX	100	1.0" & 1.25"	235/6.7	2900/1318
600	10T, 20AX	89	1.25" & 1.50"	286/8.1	3650/1656
700T*	12T, 24AX	119	1.25" & 1.50"	286/8.1	3800/1727
800	18T, 24AX, 30AX	146	1.50" & 2.0"	400/11.3	4650/2109
1000	36AX, 48AX	A.R.	A.R.	C.F.	C.F.

\*Special Head Requirements  
A.R. — As Required  
C.F. — Consult Factory

## HYDRAULIC POWER UNIT SPECIFICATIONS ELECTRIC

Power Unit Model	Recommended Pump Heads	H.P.	Hose Size	Volume Cu. Ft./Cu. Mtr.	Weight Lbs./Kg.
50	3LT	15	.50" & .50"	32/.91	635/289
75	4LT, 8AX	20	.50" & .50"	32/.91	655/298
100	4T, 10AX	25	.50" & .75"	49/1.4	725/329
250	4S, 6T, 12AX, 14AX	30	.75" & 1.0"	49/1.4	310/368
400	6S, 8T, 16AX	50	1.0" & 1.25"	58/2.5	1635/743
500*	6S, 8T, 16AX	50	1.0" & 1.25"	58/2.5	1701/773
600	10T, 20AX	75	1.25" & 1.50"	58/2.5	1750/795
700*	12T, 24AX	100	1.25" & 1.50"	58/2.5	2095/952
800	18T, 24AX, 30AX	125	1.50" & 2.0"	215/6.1	4650/2114
1000	36AX, 48AX	A.R.	A.R.	C.F.	C.F.

\*Special Head Requirements  
A.R. — As Required  
C.F. — Consult Factory

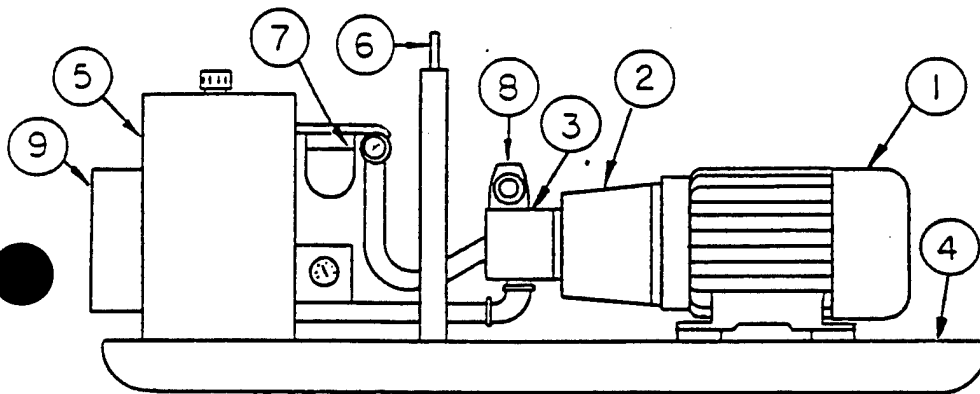


## STANDARD FEATURES

- High speed trailer or "I" beam construction skid  
Easy to move or set in place.
- Three stabilizing legs on trailer  
Keeps power unit level on any terrain.
- Prime mover can be diesel engine or electric motor. Utilizes most economical power source.
- Centralized control and gauge panel  
Easy start up and monitoring of system.
- Automatic safety shutdowns  
Protection for low hydraulic oil, high hydraulic oil temp., low engine oil pressure and high engine temperature.
- Prime mover and hydraulic pump close couples  
No hydraulic pump failures due to belt drives.
- Hydraulic oil suction strainer, return filter, tank filter breather. Protects hydraulic system against dirt contamination.
- Large fuel tank  
24 hours of run time or more.
- Control valve unloads hydraulic system  
Start and shutdown are done with no load.
- 50' of pressure and 50' return hydraulic hose  
Power unit can be remotely located for safety.
- Spin-on hydraulic hose connection  
Fast and easy setup.

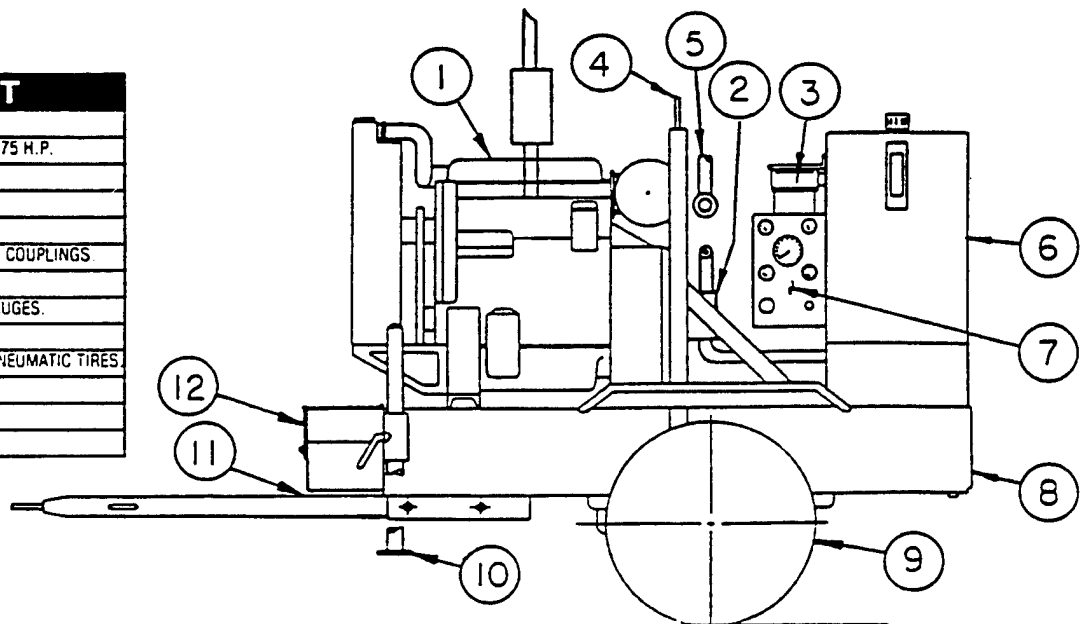
## OPTIONS

- Tandem or Variable Displacement Pump
- Extra Hydraulic Hose (up to 150')
- Flow Control to Operate Tools
- Generator or Air Compressor Drive.



ELECTRIC POWER UNIT	
ITEM	DESCRIPTION
1	MOTOR-ELECTRIC, 15 TO 150 H.P.
2	HYDRAULIC PUMP TO MOTOR ADAPTER
3	PUMP-HYDRAULIC, 4 TO 86 G.P.M.
4	SKID.
5	HYDRAULIC RESERVOIR.
6	ROLL BAR & LIFTING BRACKET.
7	FILTER-RETURN LINE, SPIN ON.
8	HYDRAULIC HOSE W/QUICK DISCONNECT COUPLINGS.
9	ELECTRIC MOTOR CONTROL PANEL.

DIESEL POWER UNIT	
ITEM	DESCRIPTION
1	ENGINE-DIESEL, WATER COOLED, 22 TO 175 H.P.
2	PUMP-HYDRAULIC, 8 TO 86 G.P.M.
3	FILTER-RETURN LINE, SPIN-ON.
4	ROLL BAR & LIFTING BRACKET.
5	HYDRAULIC HOSE W/QUICK DISCONNECT COUPLINGS.
6	HYDRAULIC RESERVOIR.
7	ENGINE ELECTRIC CONTROL PANEL W/GAUGES.
8	FUEL TANK-SELF-CONTAINED.
9	AXLE ASS'Y-HIGH SPEED 1, 2 OR 3 AXLE, PNEUMATIC TIRES.
10	ADJUSTABLE LEGS.
11	REMOVEABLE TONGUE.
12	BATTERY-12 VOLT.



Corp. & Mfg. Facilities  
D&D Machine & Hydraulics, Inc.  
10945 Metro Parkway S.E.  
Fort Myers, FL 33912  
813-275-7177 — 813-275-5350 FAX  
Cable DD Pumps — Telex 759033

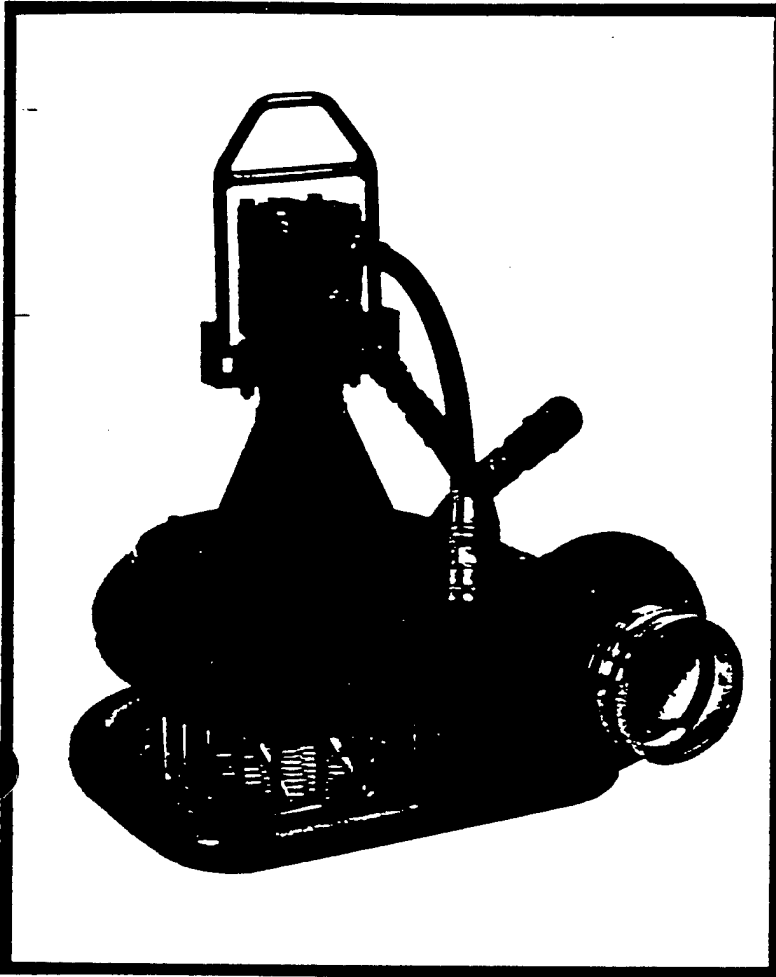


N.E. Regional Sales Office  
Commercial Ave.  
Hudson, N.H. 03051  
603-886-0522  
FAX 603-889-6379



**DEWATERING  
DESIGNERS  
PUMPS**

# TRASH PUMP



## SUBMERSIBLE OPEN TYPE TRASH PUMP

Submersible Trash Pumps are designed to pump water containing solids such as mud, weeds, trash, sticks and other foreign materials which can not be pumped with conventional centrifugal pumps.

The semi-open intake design permits the inflow of water at varying rates and does not require any suction lines. As the inflow of water increases or decreases, the pump motor can be regulated to handle the varying conditions at maximum efficiency and minimum wear on the pump head.

Whatever the dewatering requirement may be; from gradual seepage of water into a manhole; the dewatering of a borrow pit or quarry that requires the removal of millions of gallons of water per day; there is a D & D built pump for the job.

Trash pumps are available in sizes 3" through 18".

## TRASH PUMP SPECIFICATIONS

Size	Weight Lbs - Kg	Volume Cu Ft - Cu Mtr	Capacity @ 20' - 6.1 Mtr G.P.M. - Ltr P.M	Required Hydraulic Oil GPM	Power Unit Required	Horse- Power
3LT	50/23	2.2/06	450/1,703	8	50	16
4LT	57/26	3.2/09	700/2,649	10/12	60/75	19
4T	67/30	3.6/10	710/2,687	12	100	22
6T	335/152	11.8/33	1,700/6,434	18	250	40
8T	490/222	25.4/72	2,875/10,882	44	400	65
10T	620/281	31.4/90	4,400/16,554	61	600	89
12T	720/327	40.7/115	5,250/19,871	80	700	119
18T	847/384	44.7/126	7,100/26,873	86	800	146



**TRASH  
IMPELLER**

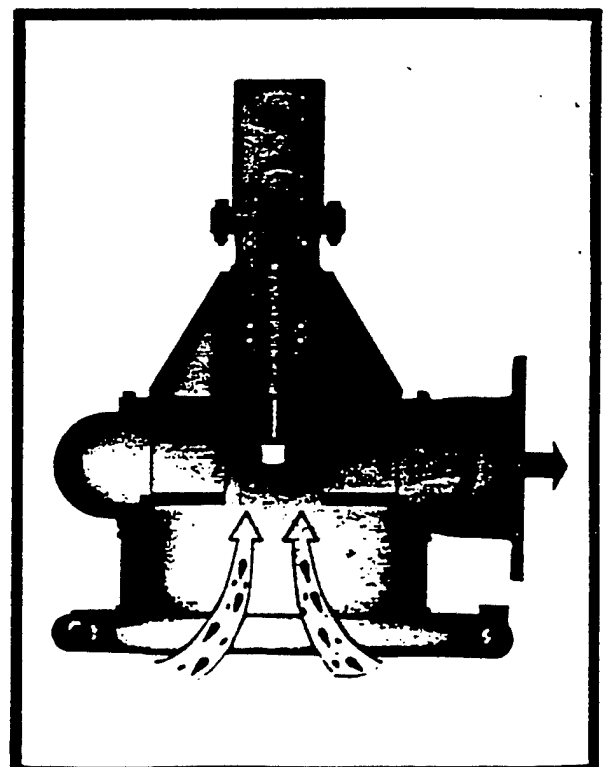
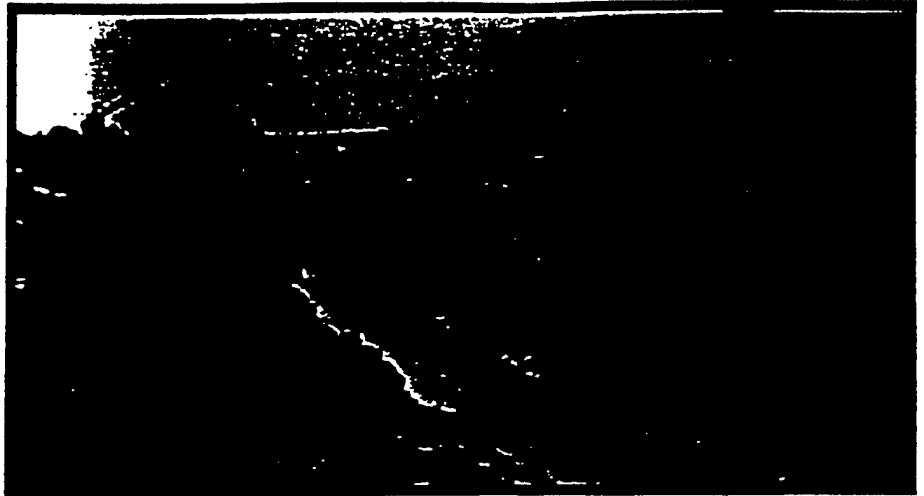


FIGURE 5

## WHY HYDRAULIC SUBMERSIBLE TRASH PUMPS??

- Easy Setup
- Remote Portable Power Source
- Can Run Dry
- Regulate Flow
- No Priming Required
- Self-Monitoring  
Safety Shutdowns
- Multiple Pumps From  
One Power Unit
- Extreme Head Capabilities



## APPLICATIONS

- **CONSTRUCTION** •  
Manhole - Sewer by Pass - Lakes -  
Canals - Pipe Laying - General Excavation
- **MINING** •  
Gravel Pits - Open Pit Mines  
Settling Ponds - Shaft Mines
- **AGRICULTURE** •  
Field Drying - Irrigation - Flood Control  
Livestock Watering

## STANDARD FEATURES AND BENEFITS

- Special Hydraulic Motor  
Provides Bearing Lubrication
- Cast Steel Bearing Tube  
Oil Bath Bearing Lubrication
- 304 Stainless Steel Pump Shaft  
Long Pump Life
- Two Sets of Ball Bearings  
No Side Load Wear
- Cast Iron Volute and Impeller  
Uniform Performance
- #125 Discharge Flange  
Easy Connection
- Lifting Bale  
Easy to Move
- Inlet Screen  
Keeps Out Oversized Objects
- Spin on Hydraulic Connectors  
Fast Setup

## OPTIONS

- Epoxy Coating
- All Stainless Steel Pump
- Discharge Flange to Pipe Adapter 90° - straight

Corp. & Mfg. Facilities  
D&D Machine & Hydraulics, Inc.  
10945 Metro Parkway S.E.  
Fort Myers, FL 33912  
813-275-7177 • 813-275-5350 FAX  
Cable DD Pump • Telex 759033



**DEWATERING  
DESIGNERS  
PUMPS**

N.E. Regional Sales Office  
Commercial Ave.  
Hudson, N.H. 03051  
603-886-0522  
FAX 603-889-6379

CHASKA MOIST SOIL UNIT							
MOIST SOIL UNIT CELLS							
ACCOUNT				UNIT		CONTINGENCIES	
CODE	ITEM	UNIT	QUANTITY	PRICE	AMOUNT	AMOUNT	PERCENT
06.3.-.-	WILDLIFE FACILITIES						
06.3.-.-	MOB., DEMOB., PREP.,	JOB	1	6,000.00	6,000.00	600	10.00%
06.3.3.B	STRIPPING	CY	13,084	0.25	3,300.00	700	20.00%
06.3.3.B	EXCAVATION	CY	4,422	2.25	9,900.00	3,000	30.00%
06.3.3.B	DREDGING	CY	30	21.50	600.00	400	65.00%
06.3.3.B	IMPERVIOUS FILL	CY	12,858	3.07	39,500.00	11,900	30.00%
06.3.3.B	AGGREGATE BASE COURSE	CY	794	9.70	7,700.00	1,500	20.00%
06.3.3.B	BEDDING	CY	26	24.40	600.00	200	25.00%
06.3.3.B	RIPRAP	CY	44	36.00	1,600.00	400	25.00%
06.3.3.B	SURGE ROCK	CY	1,398	27.65	38,700.00	9,700	25.00%
06.3.3.B	DRAINAGE FILL	CY	5	22.30	100.00	0	0.00%
06.3.3.B	TOPSOIL	CY	7,895	10.70	84,500.00	25,400	30.00%
06.3.3.B	SEEDING	ACR	2	1,950.00	3,900.00	800	20.00%
06.3.3.B	CONTROL STRUCTURE NO. 2	JOB	1	6,400.00	6,400.00	1,900	30.00%
06.3.3.B	CONTROL STRUCTURE NO. 3	JOB	1	6,400.00	6,400.00	1,900	30.00%
06.3.3.B	CONTROL STRUCTURE NO. 4	JOB	1	4,600.00	4,600.00	1,400	30.00%
06.3.3.B	CONCRETE WALL	JOB	1	2,500.00	2,500.00	800	30.00%
06.3.4.Q	MECHANICAL	JOB	1	26,000.00	26,000.00	6,500	25.00%
	TOTAL ESTIMATE COST				242,300		
	CONTINGENCIES			27.7%		67,100	
	TOTAL ESTIMATED COST AND CONTINGENCIES					309,400	
CHASKA LAKE DITCH							
06.3.-.-	WILDLIFE FACILITIES						
06.3.1.-	MOB., DEMOB., PREP.,	JOB	1	1,000.00	1,000.00	100	10.00%
06.3.3.B	CLEARING AND GRUBBING	ACR	0.50	3,250.00	1,600.00	300	20.00%
06.3.3.B	STRIPPING	CY	736	3.10	2,300.00	500	20.00%
06.3.3.B	EXCAVATION	CY	3,275	1.25	4,100.00	1,200	30.00%
06.3.3.B	DREDGING	CY	275	17.30	4,800.00	2,900	60.00%
06.3.3.B	IMPERVIOUS FILL	CY	40	5.30	200.00	100	30.00%
06.3.3.B	AGGREGATE BASE COURSE	CY	38	10.75	400.00	100	25.00%
06.3.3.B	BEDDING	CY	75	22.60	1,700.00	400	25.00%
06.3.3.B	RIPRAP	CY	147	32.40	4,800.00	1,200	25.00%
06.3.3.B	TOPSOIL	CY	70	6.95	500.00	200	30.00%
06.3.3.B	SEEDING	ACR	0.13	1,950.00	300.00	100	30.00%
06.3.4.Q	CONTROL STRUCTURE NO. 1	JOB	1	9,100.00	9,100.00	2,700	30.00%
	TOTAL ESTIMATED COST				31,000		
	CONTINGENCIES			32.26%		10,000	
	TOTAL ESTIMATED COST AND CONTINGENCIES					41,000	
	TOTAL WILDLIFE FACILITIES					\$350,000	





# United States Department of the Interior

TAKE  
PRIDE IN  
AMERICA

FISH AND WILDLIFE SERVICE  
Minnesota Valley National Wildlife Refuge  
3815 East 80th Street  
Bloomington, Minnesota 55425-1600

April 27, 1993

## Memorandum

To: Dave Raasch, Project Management Office, Army Corps of Engineers  
From: Refuge Manager, Minnesota Valley National Wildlife Refuge  
Subject: Comments on Latest Chaska Flood Control Mitigation Design

The latest plans appeared very thorough and most the items agreed upon during the cooperative effort over the years were incorporated.

The following items were not clearly defined and need to be confirmed:

Page 4.17-This paragraph is interpreted as intending that all dikes will be 3 to 1 slopes. Our notes and recollection are that only riprapped dikes would have 3 to 1 slopes and unriprapped would be sloped 4 or 5 to 1. Drawing # M34-CH-R-5/236 in the note section reads 5 to 1. We have recently purchased equipment that will allow us to mow dikes without taking equipment on the slope. We now propose that 4 to 1 slopes on unriprapped dikes would be preferred as it would reduce damage from burrowing animals and our mowing equipment will reach the toe of the dike.

Page 8.35-The third sentence in this paragraph states that riprap is recommended at the entrance and exit. Terry M. Schreiner reported that it was decided during a conference phone conversation on 1/28/93 with you and other staff that riprap would definitely be needed at both ends of this structure. We strongly believe that this area needs protection.

I would like to take this opportunity to commend you and all the staff involved in this project over the years. The communication and working relationships have been excellent. This kind of cooperative effort can only improve our collective future efforts.

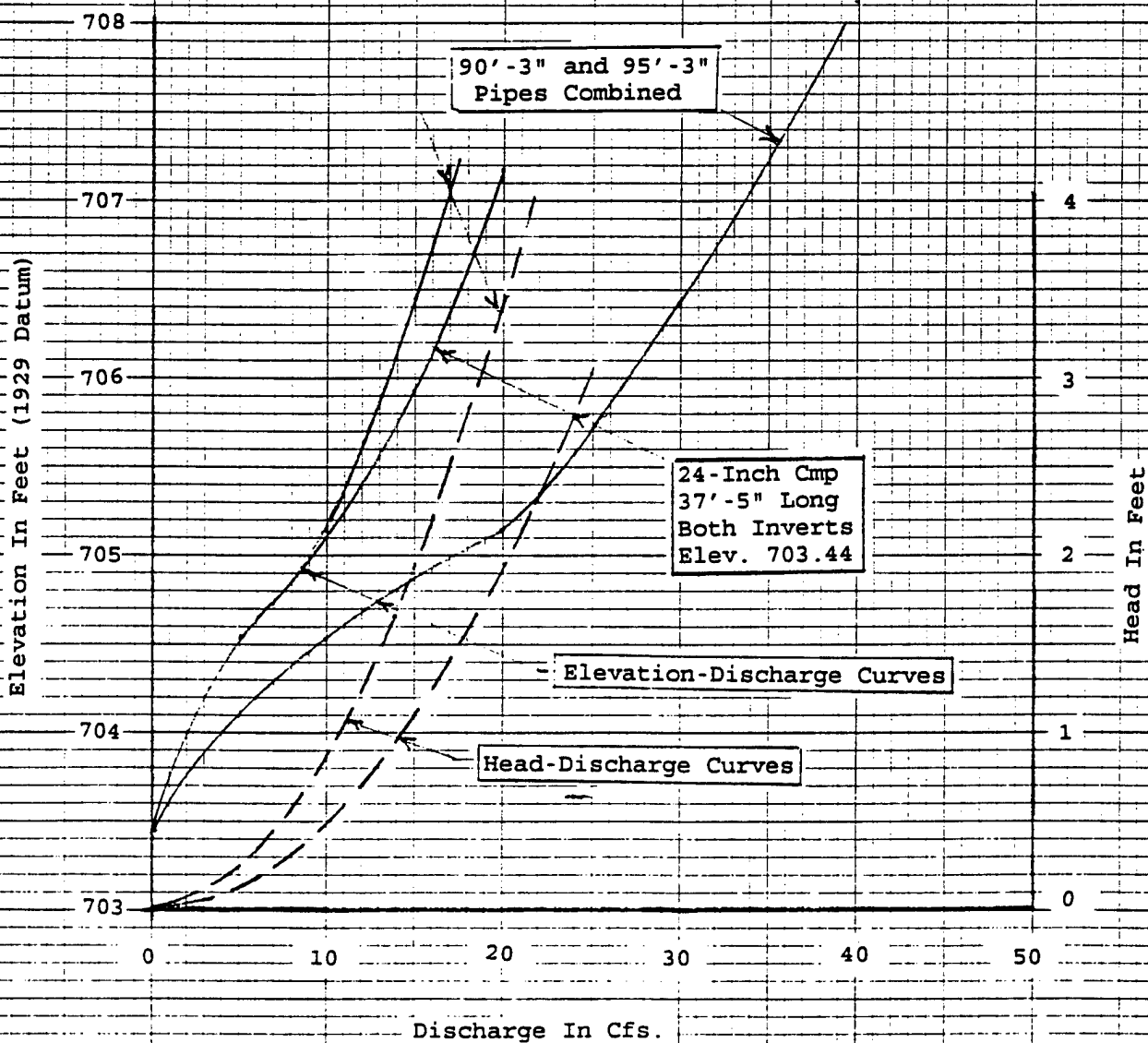
Thomas J. Larson

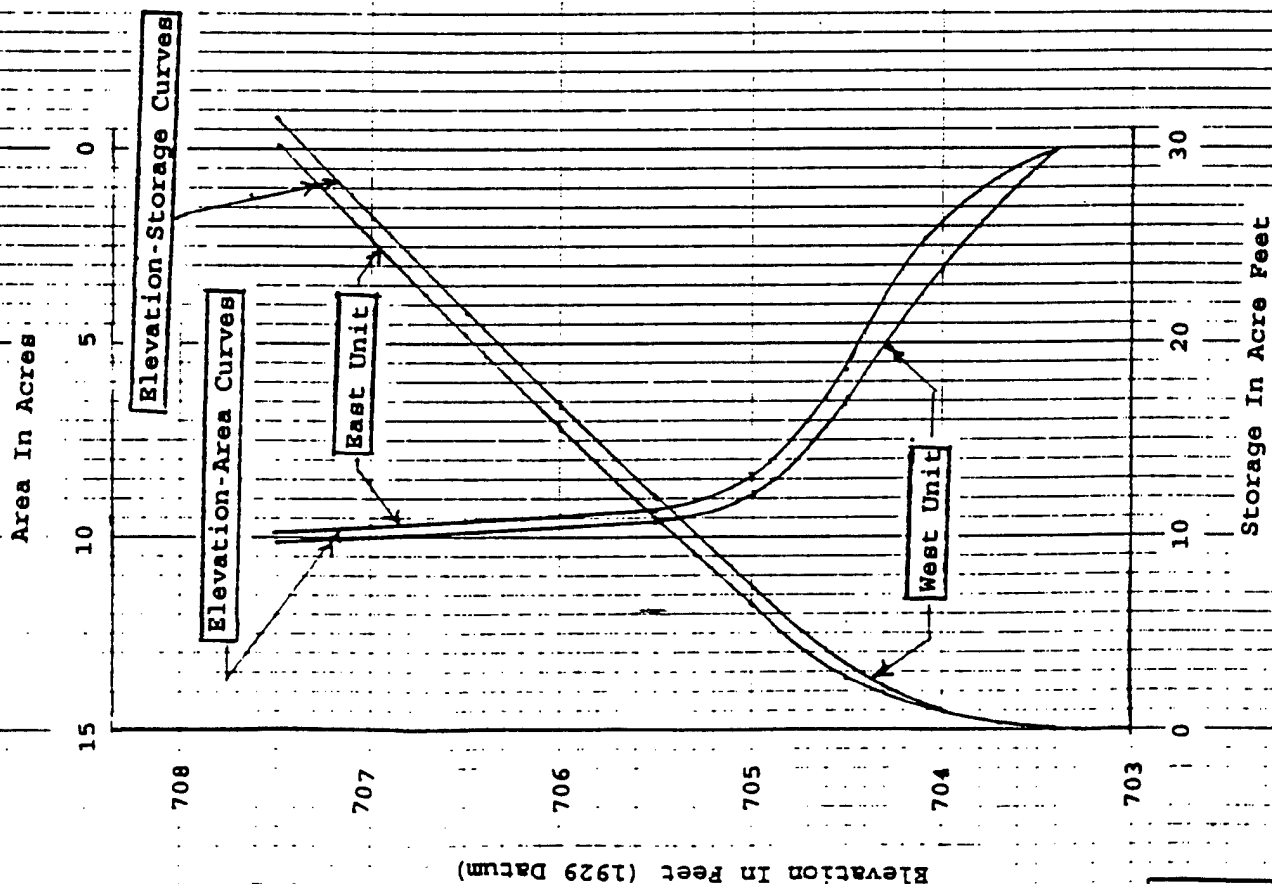
cc: Gary Wege, Twin Cities Field Office

24-Inch Cmp  
90'-3" Long  
Invert Elevs:  
Upstrm: 703.44  
Dwnstm: 703.10

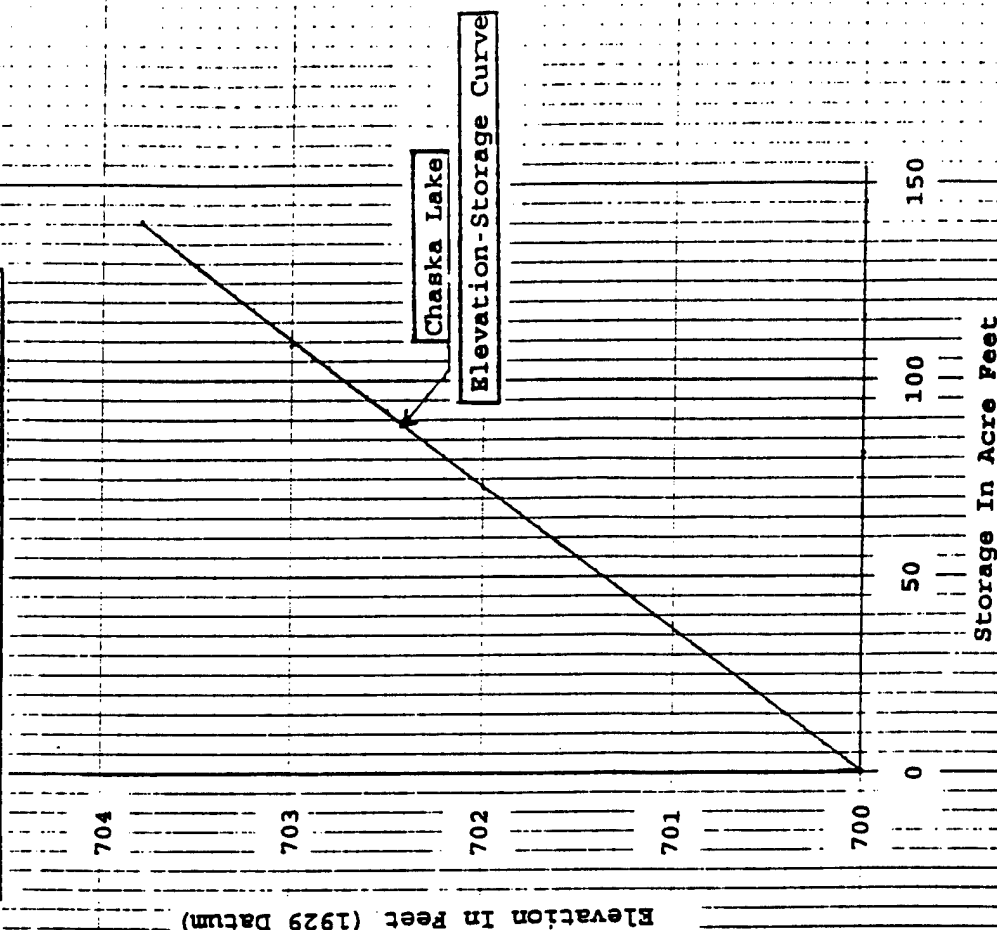
24-Inch Cmp  
95'-3" Long  
Invert Elevs:  
Upstrm: 703.44  
Dwnstm: 703.10

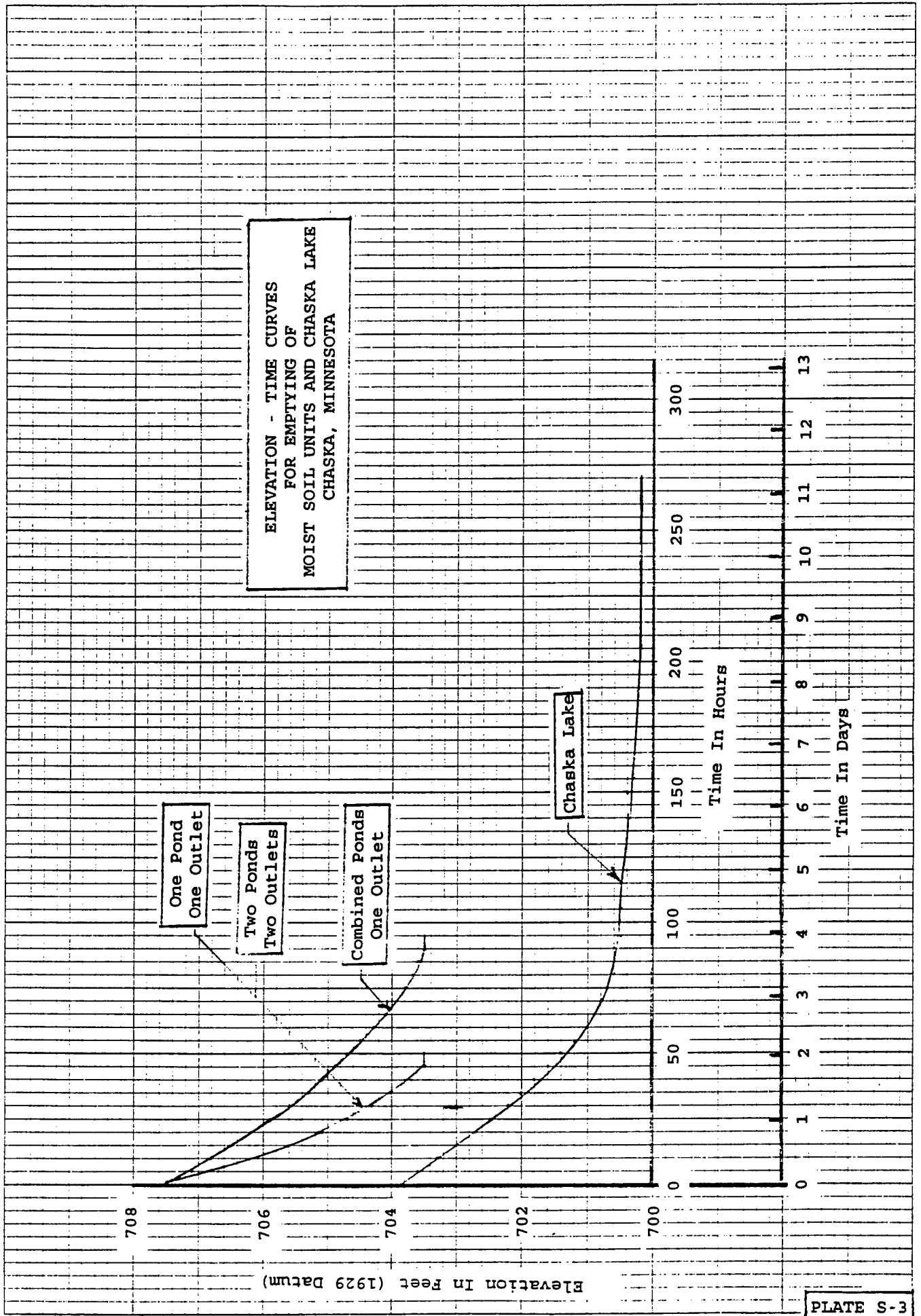
ELEVATION - DISCHARGE - HEAD CURVES  
FOR PROPOSED 24-INCH CMP'S  
FOR MOIST SOIL UNITS  
CHASKA, MINNESOTA

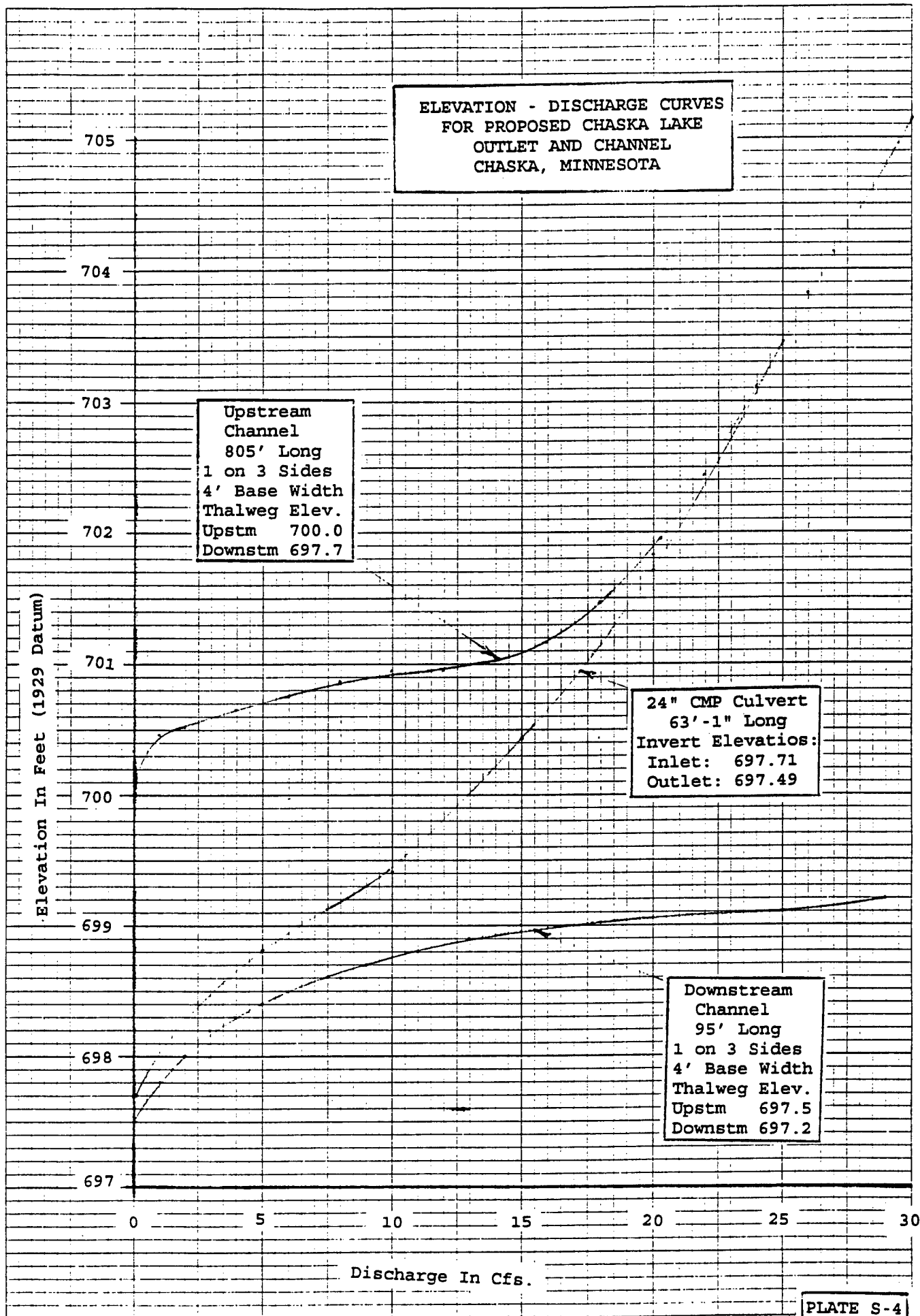


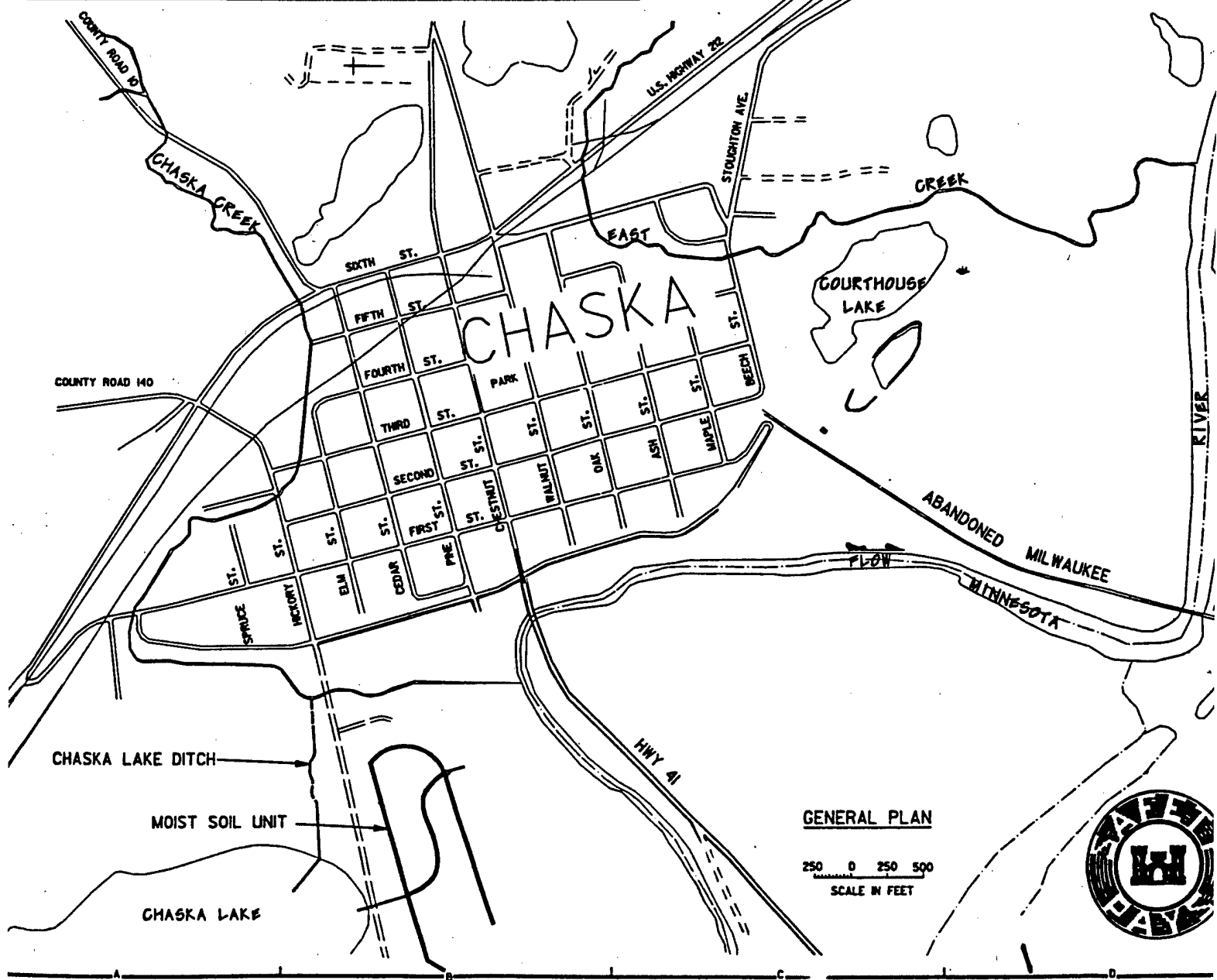


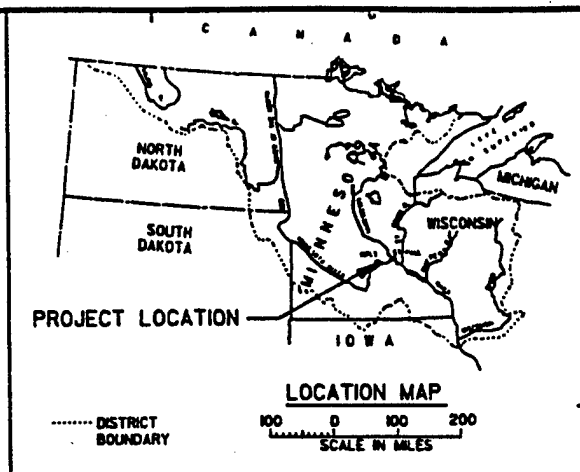
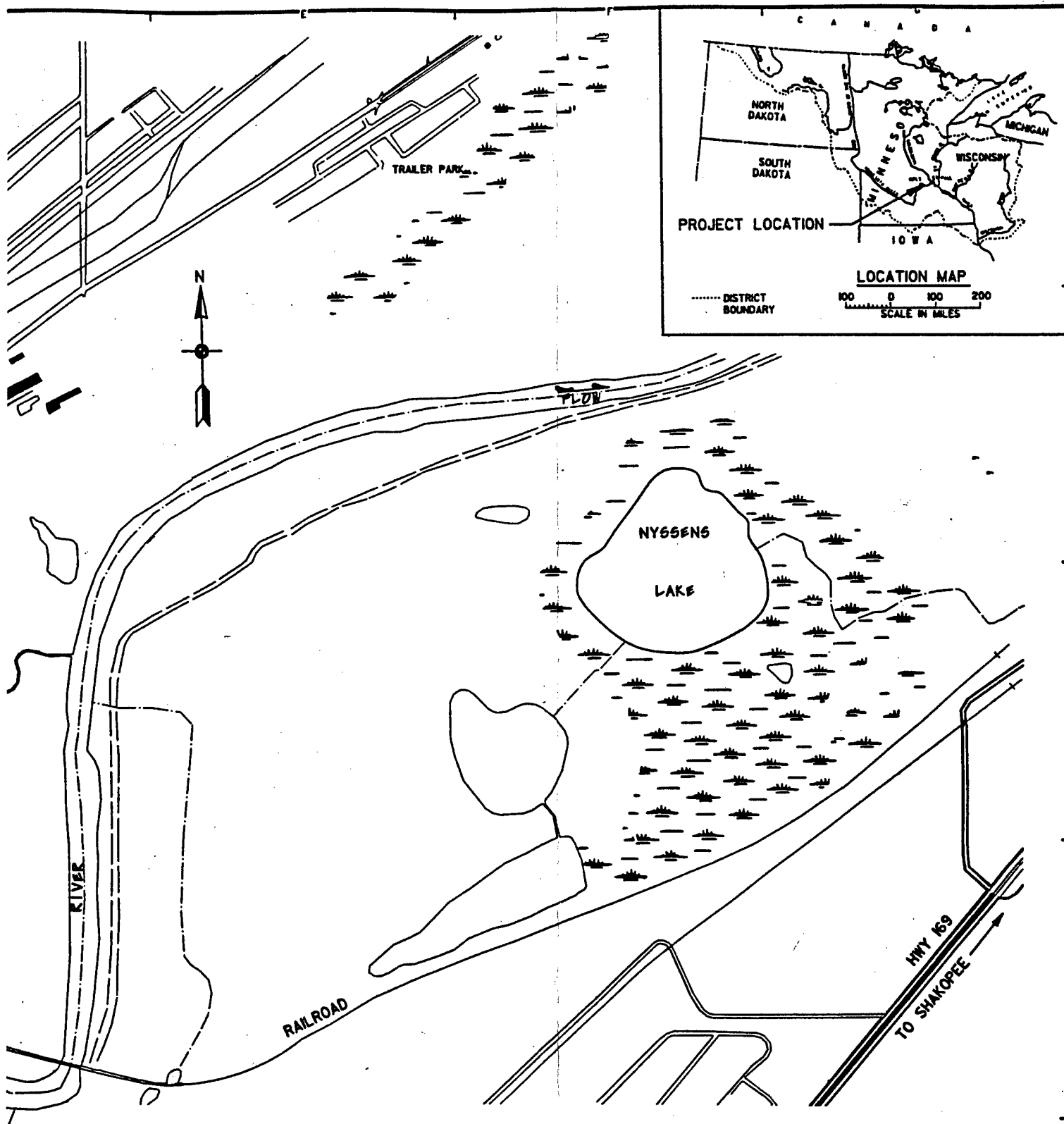
ELEVATION - AREA - STORAGE CURVES  
MOIST SOIL UNITS AND CHASKA LAKE  
CHASKA, MINNESOTA







[illegible]



SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET, AS INDEXED ON THIS SHEET.			
APPROVAL RECOMMENDED BY:		ENGINEER MANAGER	
CHEF ED-D BRANCH		CHIEF SPECS. & TECH. SUPPORT SECTION	
CHEF ED-GH BRANCH		CHIEF GENERAL ENGINEERING SECTION	
CHEF ENGINEERING DIVISION		CHIEF STRUCTURAL SECTION	
APPROVED BY:		CHIEF MECH/ELEC/ARCH SECTION	
COL. CORPS OF ENGINEERS		CHIEF HYDRAULICS SECTION	
		CHIEF HYDROLOGY SECTION	
		CHIEF GEOTECHNICAL DESIGN SECTION	

DESCRIPTION		DATE	APPROVAL
DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA			
DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA			
MOIST SOIL UNIT AND CHASKA LAKE LOCATION MAP, GENERAL PLAN AND DRAWING INDEX			
DESIGNED: M.M.B.	CAD FILE NAME: MSUCOV.DGN	DRAWING NUMBER: M34-CH-R-5/232	SHT 1 OF 9
CHECKED: T.J.L.			
DESIGNED: W.J.M.-J.R.C.			
CHECKED:			
DATE: MARCH 10, 1993	SPEC NO:		



2

THE GRAIN SIZE IN MILLIMETERS OF  
OF THE BORING STAFF.





91-149M

29 JAN 1991

91-150M

6 FEB 1991

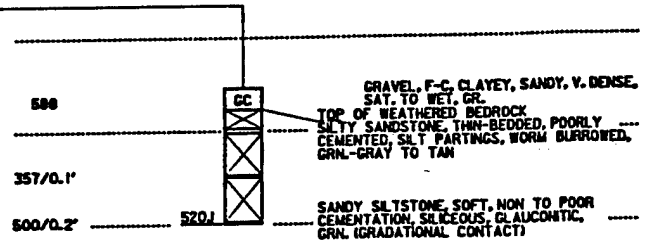
SPT	D10	MC	LL	PL
710				
		G.S. 705.3		
700	2	W.L. 698.7	OL	
			ML	
690	0		ML	
			SM	SP SEAM
680	3		ML	
			SM	
670	4		ML	SC SEAM
			SM	
660	3		ML	CL SEAM
			SM	
650	11		CL	SM SEAM
			SM	
640	8		ML	
			SP-SM	
630	20		SP	CH SEAM
			CL	
620	11		SP	CH SEAM
			GM	
610	24		SP-SM	
			SP	
600	33		SP	
			CL	
590	80		SP	
			SP	
580	121		SP	
			SP-SM	
570	145		SM	GC SEAM
			SP-SM	
560	110		SP	SC SEAM
			SP	
550	294		SP	GC SEAM
			SP-SM	
540	84		SP	CH SEAM
			SP	
530	105		SP	

## NOTES:

1. WATER LEVEL DETERMINED AFTER 30 MINUTES WITH BOTTOM OF AUGER AT EL. 698.8' AFTER SAMPLING TO EL. 693.8'
2. HOLE ADVANCED TO EL. 683.8' WITH 3" HOLLOW STEM AUGER. ALL AUGER RECOVERED AFTER COMPLETION OF HOLE.
3. HOLE BACKFILLED WITH AUGER CUTTINGS AND CAPPED WITH 30 LBS. PORTLAND CEMENT.

SPT	D10	MC	LL	PL
710				
		G.S. 703.8		
700		W.L. 701.8	OL	
			CL	
690			CL	
			SM	
680			ML	
			CL	
670			CL	
			CH	

SILT, SANDY, ORGANICS, FROZEN, SAT., BRN.-BLK.  
CLAY, SILTY, SANDY, V. SOFT, SAT., ORGANICS, DK. GR., ALLUV.  
CLAY, SILTY, SANDY, V. SOFT, WET TO SAT., ORGANICS, LT. BRN.  
CLAY, SILTY, SANDY, V. SOFT, SAT., ORGANICS, SHELL FRAGS., BRN.  
SILT, CLAYEY, SANDY, V. SOFT, MOIST TO WET, ORGANICS, SHELL FRAGS., GR.  
SAND, FINE, SILTY, LOOSE, SAT., ORGANICS, SHELL FRAGS., GR.  
SILT, CLAYEY, SANDY, V. SOFT, WET TO SAT., ORGANICS, GR.  
CLAY, SILTY, V. SOFT, MOIST, ORGANICS, SHELL FRAGS., DK. GR.  
CLAY, SILTY, V. SOFT, WET, ORGANICS, SHELL FRAGS., BRN.



## NOTES:

1. WATER LEVEL DETERMINED AFTER 75 MIN. WITH BOTTOM OF AUGER AT EL. 695.3' BOTTOM OF HOLE AT EL. 695.3' AFTER SAMPLING TO EL. 690.3'
2. 3" HOLLOW STEM AUGER ADVANCED TO ELEV. 676.3' HOLE STABILIZED WITH DRILLING MUD BELOW ELEV. 676.3' ALL AUGER RECOVERED UPON COMPLETION OF HOLE
3. NO SIGNIFICANT WATER LOSS WAS NOTED.
4. HOLE BACKFILLED WITH TREATED CEMENT-BENTONITE GROUT BEFORE HSA CASING WAS PULLED.

91-151M

7 FEB 1991

SPT D10 MC LL PL

G.S. 705.3

CH

CLAY, SILTY, ORGANICS, SOFT, WET,  
BRN.  
CLAY, SILTY, SOFT, WET, ORGANICS  
SHELL FRAGS... BRN.

699.3

CH

91-152M

7 FEB 1991

SPT D10 MC LL PL

G.S. 704.0

W.L. 701.9

CH

698.0

CH

SILT, CLAYEY, ORGANICS, V. SOFT, SAT.,  
BLK.-BRN.  
CLAY, SILTY, SOFT, MOIST TO WET,  
ORGANICS, SHELL FRAGS... BRN.

710

700

690

680

670

## NOTES:

1. WATER LEVEL AND STANDARD PENETRATION NOT DETERMINED. HOLE FILLED WITH SURFACE WATER.
2. NO CASING SET.
3. HOLE BACKFILLED WITH BENTONITE.

## NOTES:

1. WATER LEVEL DETERMINED AFTER 5.5 HOURS WITH NO CASING USED AND BOTTOM OF HOLE AT EL. 701.3' AFTER SAMPLING TO EL. 698.0'.
2. STANDARD PENETRATION NOT DETERMINED.
3. HOLE BACKFILLED WITH BENTONITE.

540

530

520

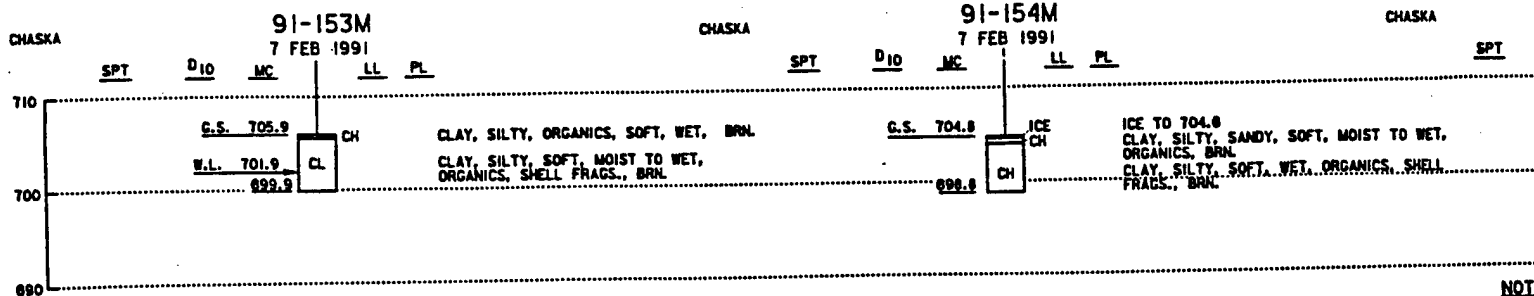
510

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SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
DESIGNED:		<p align="center">DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA MOIST SOIL UNIT AND CHASKA LAKE BORING LOGS 91-149M THRU 91-152M</p>			
CHECKED:		<p align="center">DATE: MARCH 8, 1993</p>			
DRAWN: GRS		<p align="center">SPEC NO:</p>			
DESIGNED: PAW/JRC		<p align="center">DRAWING NUMBER: M34-CH-R-5/234</p>			
CHECKED:		<p align="center">SHT 3 OF 9</p>			



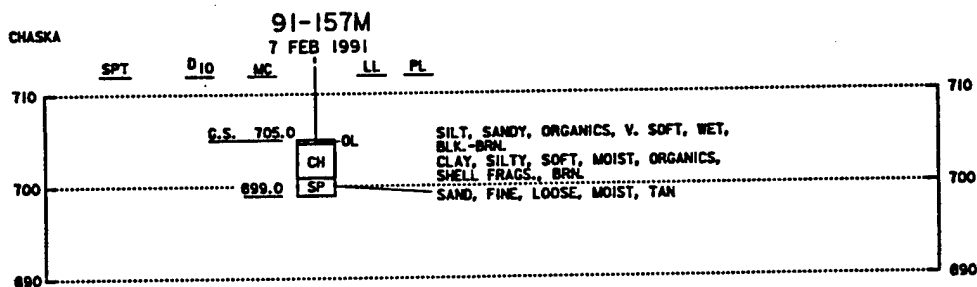
**NOTES:**

1. WATER LEVEL DETERMINED AFTER 5 HOURS WITH NO CASING USED AND BOTTOM OF HOLE AT EL. 701.0', AFTER SAMPLING TO EL. 699.9.
2. STANDARD PENETRATION TEST NOT DETERMINED.
3. HOLE BACKFILLED WITH BENTONITE.

**NOTES:**

1. WATER LEVEL NOT DETERMINED.
2. STANDARD PENETRATION NOT DETERMINED.
3. HOLE BACKFILLED WITH BENTONITE.

NOT



**NOTES:**

1. WATER LEVEL NOT ENCOUNTERED.
2. SURVEYED ELEVATIONS ARE +1.0 FT.
3. NO HSA CASING INSTALLED.
4. HOLE BACKFILLED WITH BENTONITE.

91-155M

7 FEB 1991

CHASKA

91-156M

7 FEB 1991

SPT

D10

MC

LL

PL

SPT

D10

MC

LL

PL

G.S. 704.8

CH

698.8

CLAY, SILTY, ORGANICS, SOFT, MOIST TO  
WET, BRN.  
CLAY, SILTY, SOFT, WET TO SAT., BRN.

G.S. 705.2

CH

W.L. 700.5

693.2

CLAY, SILTY, ORGANICS, SOFT, MOIST TO  
WET, BRN.  
CLAY, SILTY, SOFT, WET TO SAT.,  
ORGANICS, SHELL FRAGS., BRN.

710

700

690

## NOTES:

1. WATER LEVEL NOT DETERMINED DUE TO SURFACE WATER RUNNING INTO HOLE.
2. STANDARD PENETRATION TEST NOT DETERMINED.
3. HOLE BACKFILLED WITH BENTONITE.

## NOTES:

1. WATER LEVEL DETERMINED AFTER 90 MINUTES WITH NO CASING USED AND BOTTOM OF HOLE AT EL. 700.5.
2. STANDARD PENETRATION TEST NOT DETERMINED.
3. HOLE BACKFILLED WITH BENTONITE.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p>DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA MOIST SOIL UNIT AND CHASKA LAKE BORING LOGS 91-153M THRU 91-157M</p>			
ED-0	DESIGNED:	<p>CAD FILE NAME: NC18R402.DGN DRAWING NUMBER: M34-CH-R-5/235 DATE: MARCH 11, 1993 SPEC NO:</p>			
	CHECKED:				
	DRAWN: GRS				
	DESIGNED: PAW/JRC				
CHECKED:	<p>SHT 4 OF 9</p>				

ELEVATION AT MAX. DEPTH 700.40  
WATER SURFACE 703.85±



DREDGE TO ELEVATION 700.4  
APPROXIMATELY 800 FEET OFFSHORE  
SEE NOTE #7

RIPRAP TOP  
EMBANKMENT

CHASKA LAKE DITCH  
SEE NOTE #8

SLOPE = 0.003

INVERT EL. = 700.0

CONTROL STRUCTURE NO.  
WITH RIPRAPPED INLET-

CONTROL STP  
UPSTREAM IN  
DOWNSTREAM

EXISTING  
12" TRAIL

SHORELINE

CONCRETE PAD

PORTABLE PUMP  
LOCATION

DREDGE TO ELEVATION 701.5  
APPROXIMATELY 100 FEET OFFSHORE

MOIST SOIL UNIT  
INLET DITCH  
INVERT EL. = 701.5  
SLOPE = 0.0

CONCRETE WALL

91-150M

701.0

706.5

704.6

704.8

706.0

705.0

707.0

706.0

705.0

705.0

704.8

705.0

704.6

704.4

704.6

704.4

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705.0

707.0

706.0

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44DJ82

43DJ82

TOP AND SIDE SLOPES OF  
VENT AND CULVERT OUTLETREMOVE  
EXISTING 18" CMP  
INVERT EL. 702.72E. NO. 1  
LETSTRUCTURE NO. 1  
M INVERT EL. = 697.7  
TEAM INVERT EL. = 697.5RAISE TOP OF EMBANKMENT TO 705.0  
TIE INTO EXISTING GROUND AT 705.0 OR GREATERREALIGN TRAIL  
EXISTING 12' TRAIL

AREA 2A

83-53M

FULL ROCK  
PROTECTIONVEHICLE ACCESS RAMP  
(24' WIDE @ 100)

103.6

CONTROL STRUCTURE NO. 2  
WITH RIPRAPPED INLET707.0 VEHICLE ACCESS RAMP  
(24' WIDE @ 102 TO EL. 707)RIPRAP  
INVERT EL. = 703.1**NOTES:**

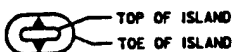
1. THE OUTSIDE LEVEE ELEVATION IS 707.0, THE INSIDE LEVEE ELEVATION IS 706.5, THE MAXIMUM DESIGN WATER SURFACE IS ELEVATION 705.5.
2. ALL ISLANDS HAVE 12' TOP WIDTHS AND IV ON 20H SIDESLOPES.
3. ALL ELEVATIONS SHOWN ARE 1929 ADJUSTED.
4. ALL LEVEES HAVE 12' TOP WIDTHS. LEVEES PROTECTED WITH SURGE ROCK HAVE IV ON 3H SIDE SLOPES. UNPROTECTED LEVEES HAVE IV ON 5H SIDE SLOPES.
5. THE MOIST SOIL UNIT OUTLET DITCH HAS A 15' BASE WIDTH AND IV ON 3H SLOPES.
6. THE CHASKA LAKE OUTLET DITCH HAS A 4' BASE WIDTH AND IV ON 3H SLOPES.
7. CHASKA LAKE SHALL BE DREDGED SUCH THAT TWO TRAPEZOIDAL CHANNELS WITH 4' WIDE BASE WIDTHS WILL BE CONSTRUCTED. THE CHANNEL FOR DRAINING CHASKA LAKE WILL HAVE AN INVERT OF 700.4'. THE INVERT FOR THE MOIST SOIL UNIT INLET DITCH WILL BE 701.5'.

**REFERENCES:**

1. CONTROL STRUCTURE
2. BORINGS

**LEGEND:**

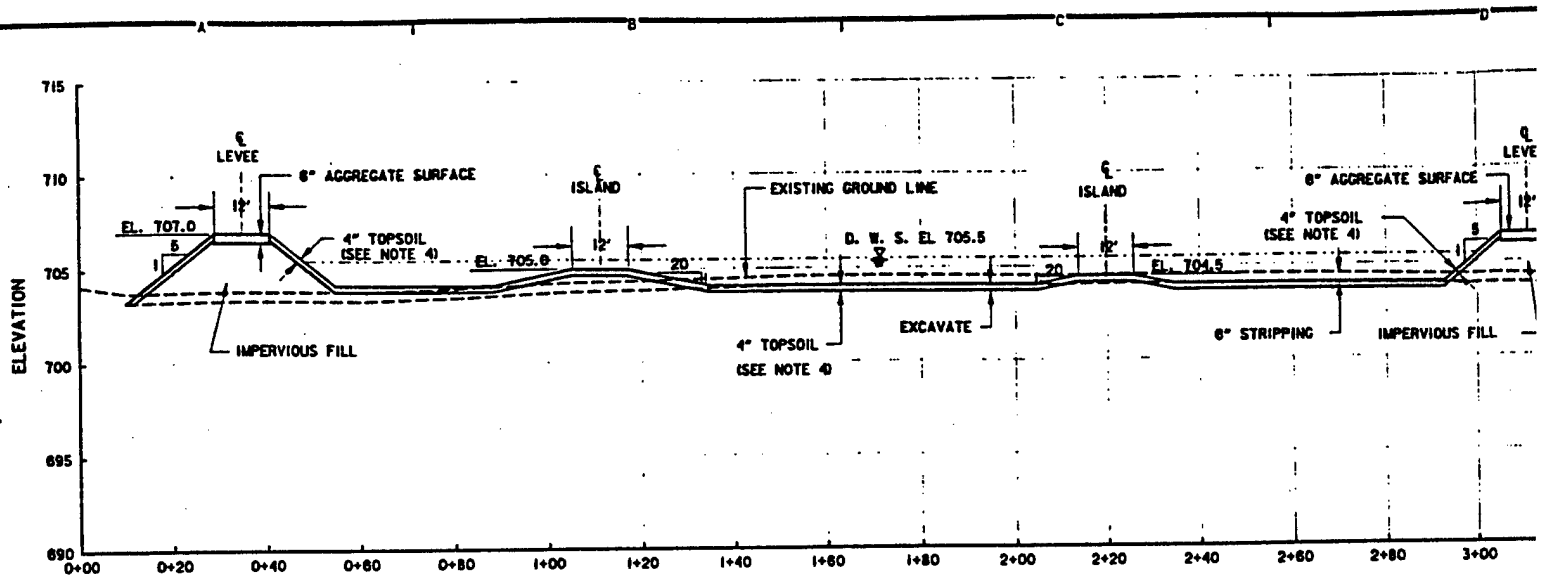
- 703.66 - DENOTES PROPOSED ELEVATIONS  
7.000 - DENOTES EXISTING ELEVATIONS

**DWG. NO.**

5/236  
5/233, 5/234

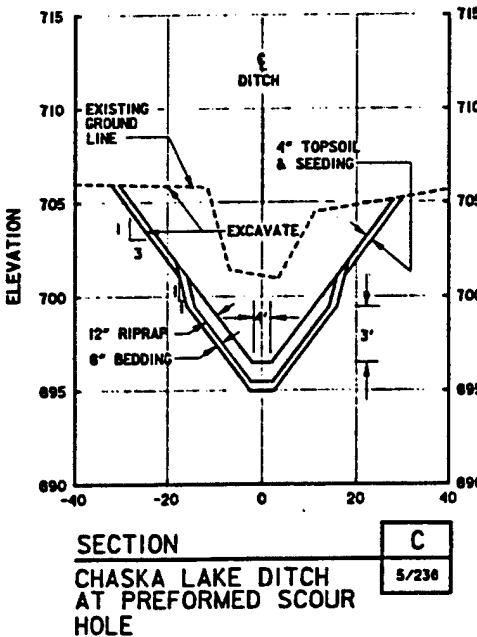
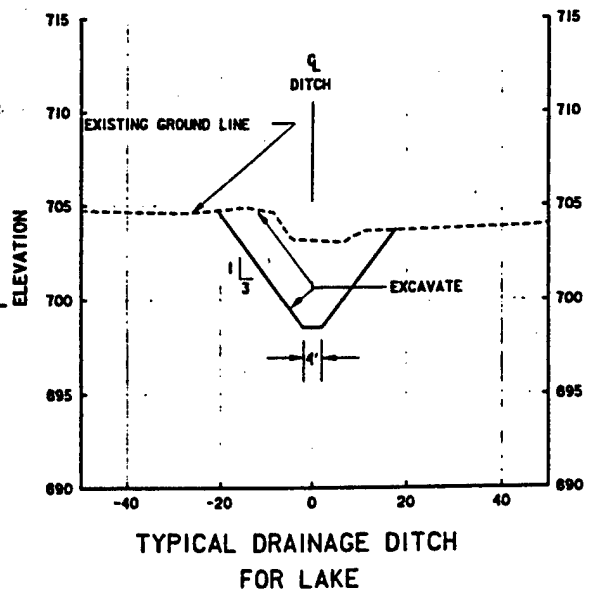
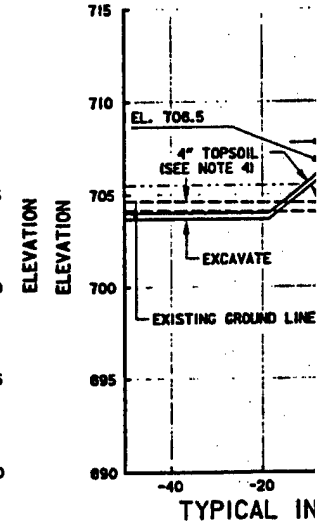
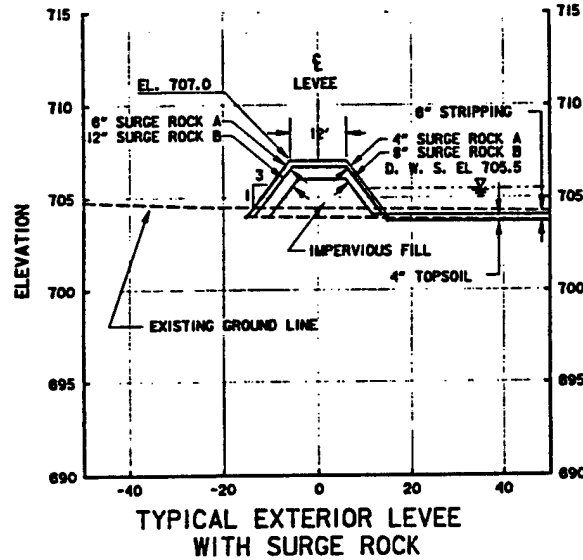
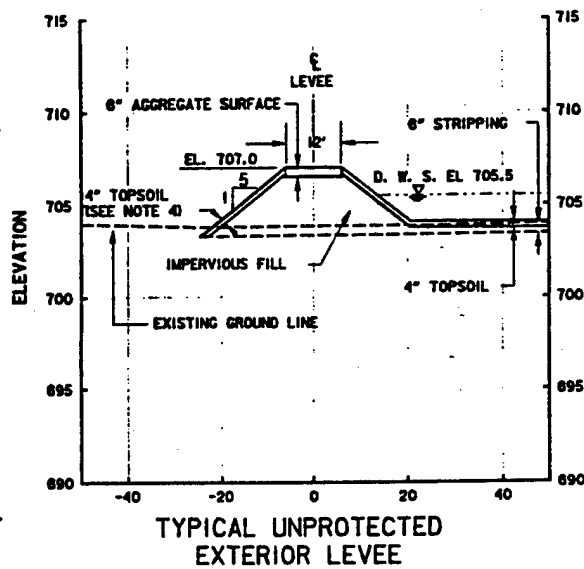
NEW 42DJ82

SYMBOL		DESCRIPTION		DATE	APPROVAL
<b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA					
AE APPROVING OFFICIAL: _____		DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA MOIST SOIL UNIT AND CHASKA LAKE CONTROL STRUCTURE GENERAL PLAN			
DESIGNED: CHECKED: DRAWN: DESIGNED: CHECKED: DATE: MAR. 10, 1993	DESIGNED: MMB T.L.J. CHECKED: MMB DRAWN: MMB	CAD FILE NAME: MSU3D.DGN SPEC NO:		DRAWING NUMBER: <b>M34-CH-R-5/236</b>	
	SHEET 8 OF 7				

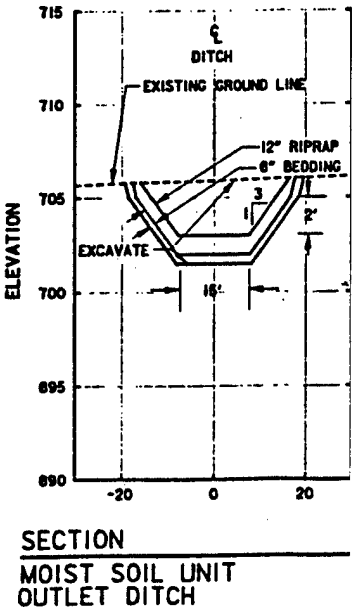


SECTION

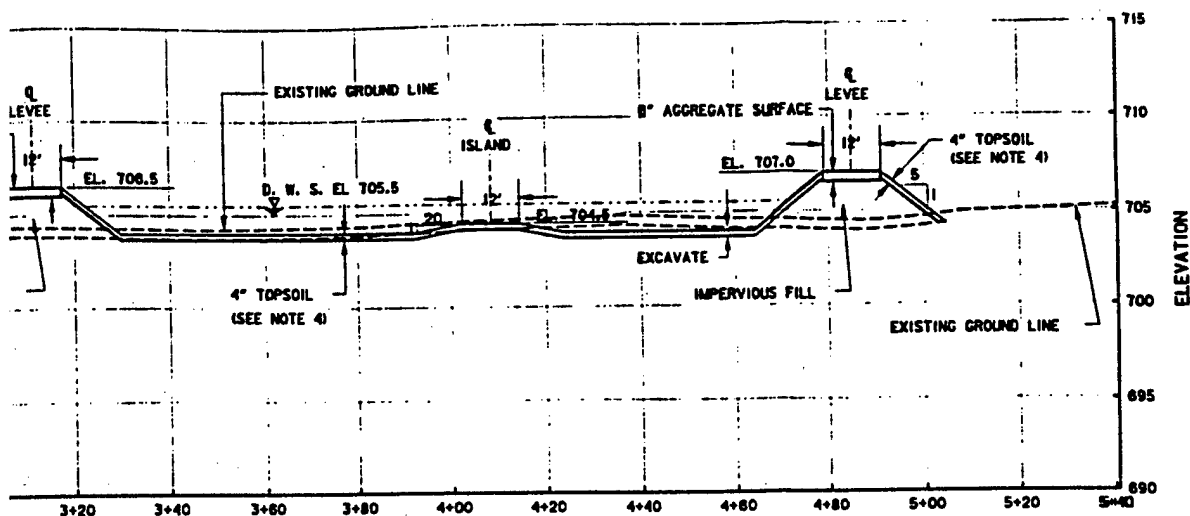
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5/236



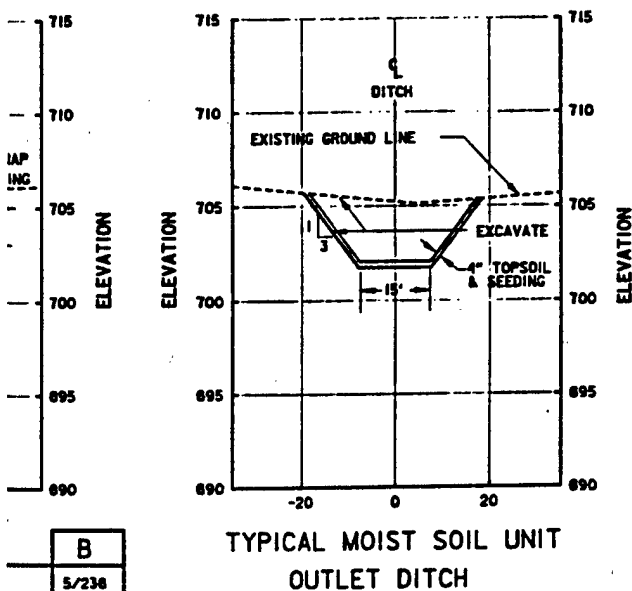
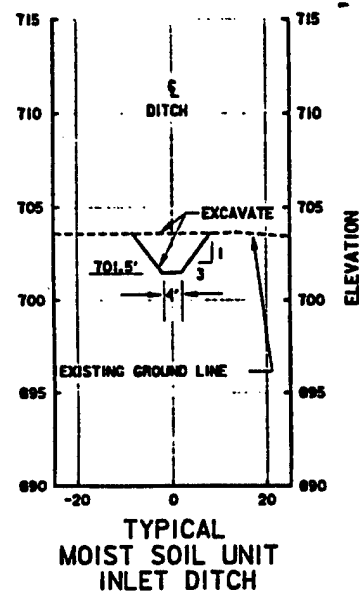
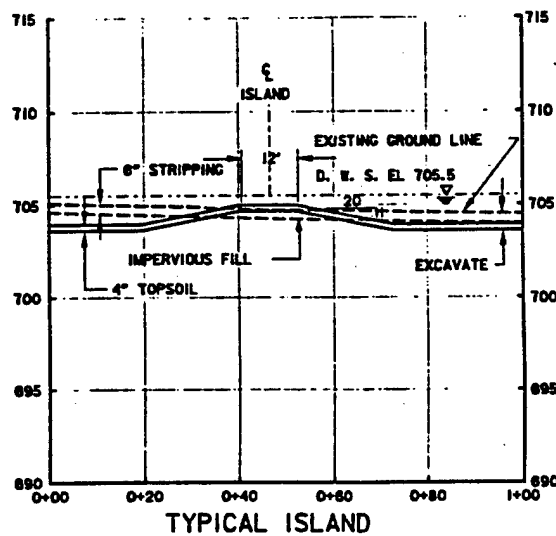
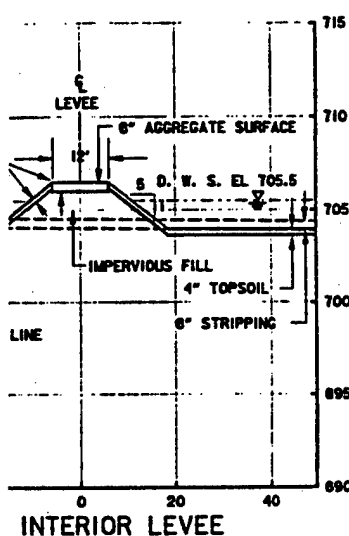
C  
5/236







A  
5/236



### NOTES:

1. ALL ELEVATIONS SHOWN ARE MSL 1929 ADJ.
  2. SECTIONS DRAWN LOOKING DOWNSTREAM.
  3. D. W. S. MEANS THE DESIGN WATER SURFACE
  4. ALL LEVEE SLOPES WITH 4" TOPSOIL SHALL BE SEEDDED.
- ISLANDS AND INTERMEDIATE AREAS SHALL NOT BE SEEDDED.

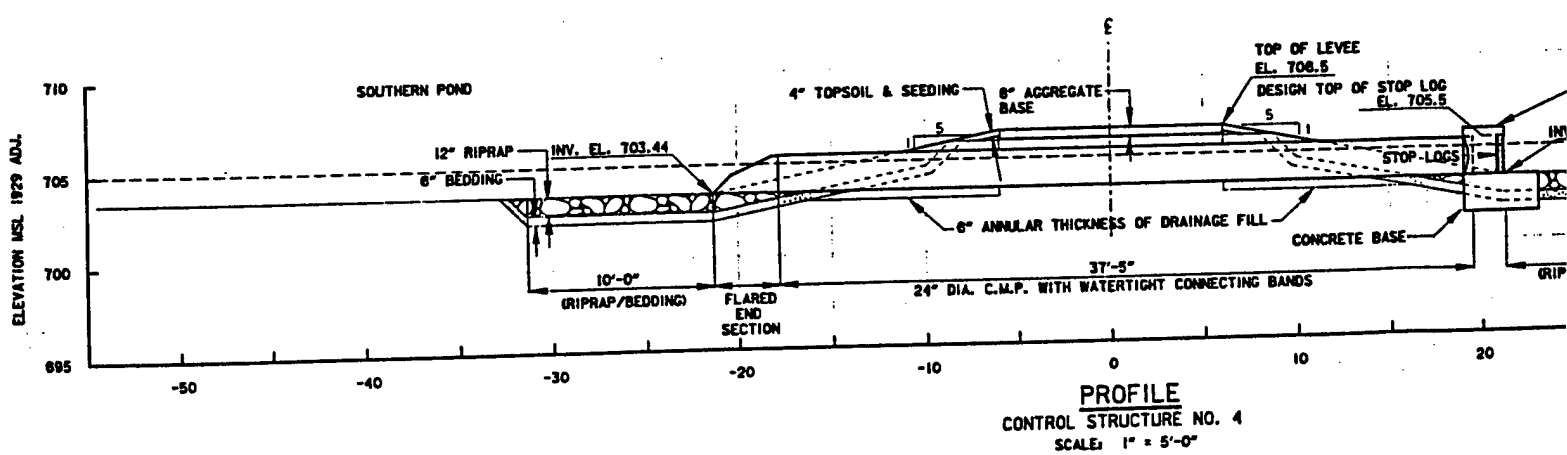
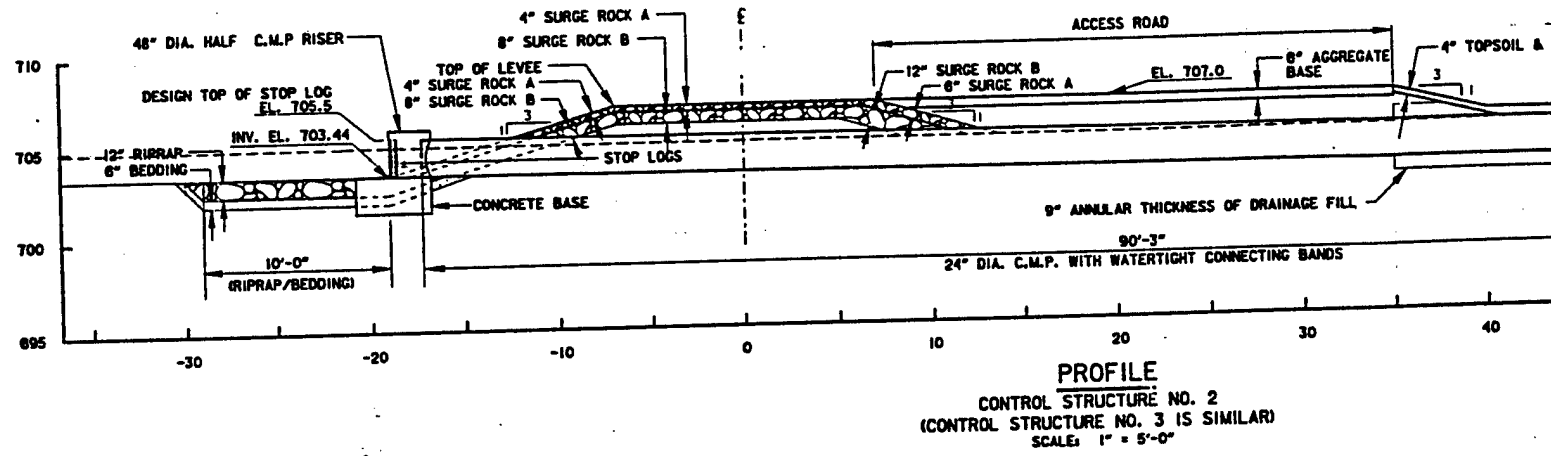
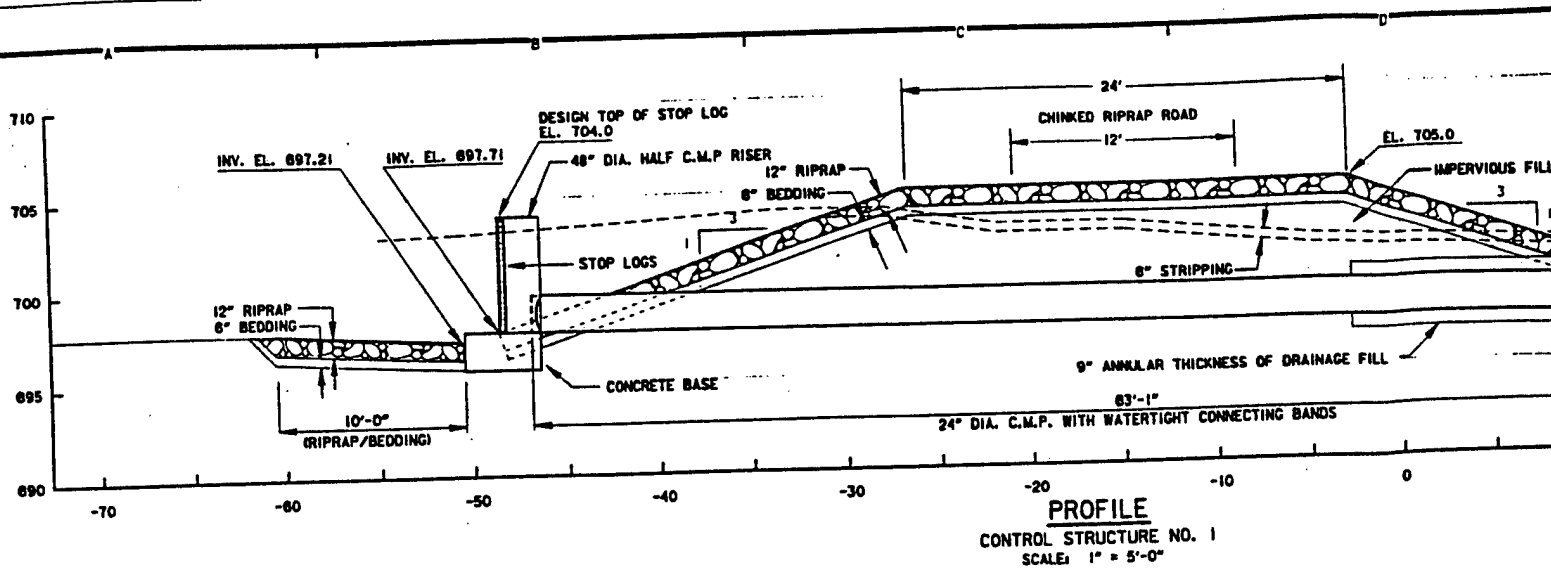
### REFERENCES:

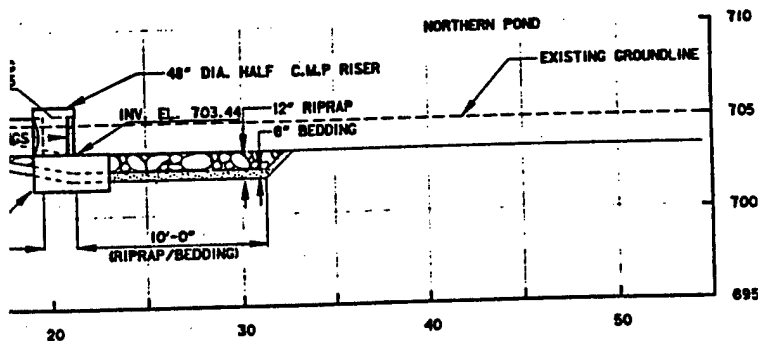
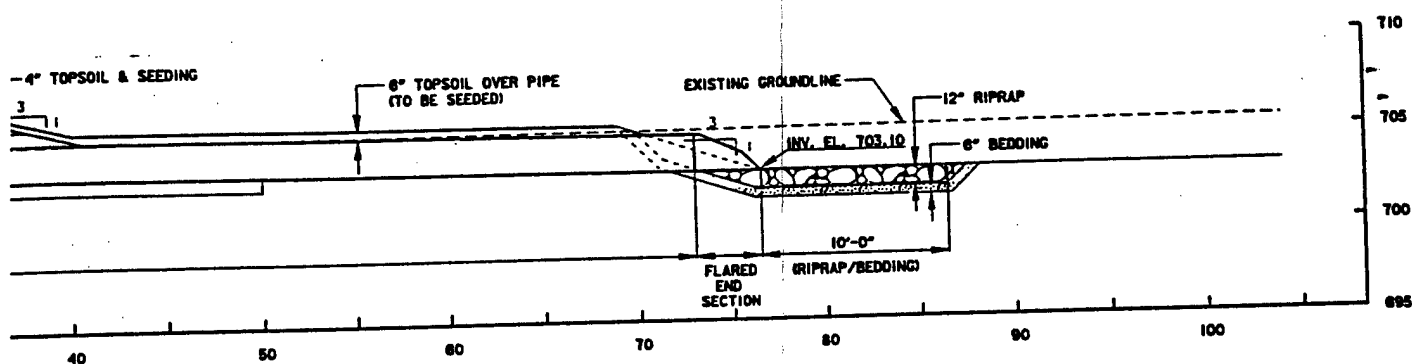
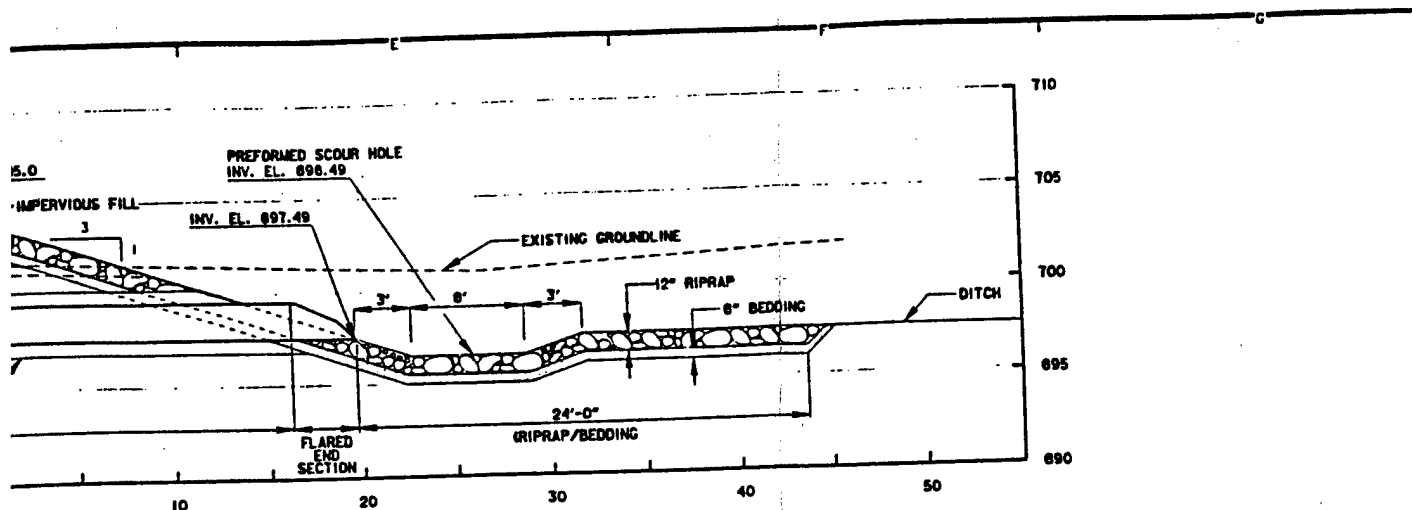
CONTROL STRUCTURE

### DWG NO.

5/236

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA</p>			
<p>DESIGNED: MMB TLJ</p>		<p>MOIST SOIL UNIT AND CHASKA LAKE DIKE, ISLAND, AND DITCH CROSS SECTIONS</p>			
<p>CHECKED:</p>		<p>CAD FILE NAME: MSLX53.DGN</p>			
<p>DRAWN: MMB TJ</p>		<p>DRAWING NUMBER: M34-CH-R-5/237</p>			
<p>DESIGNED:</p>		<p>SHT 8</p>			
<p>CHECKED:</p>		<p>OF 9</p>			
<p>DATE: MARCH 11, 1993</p>		<p>SPEC NO:</p>			

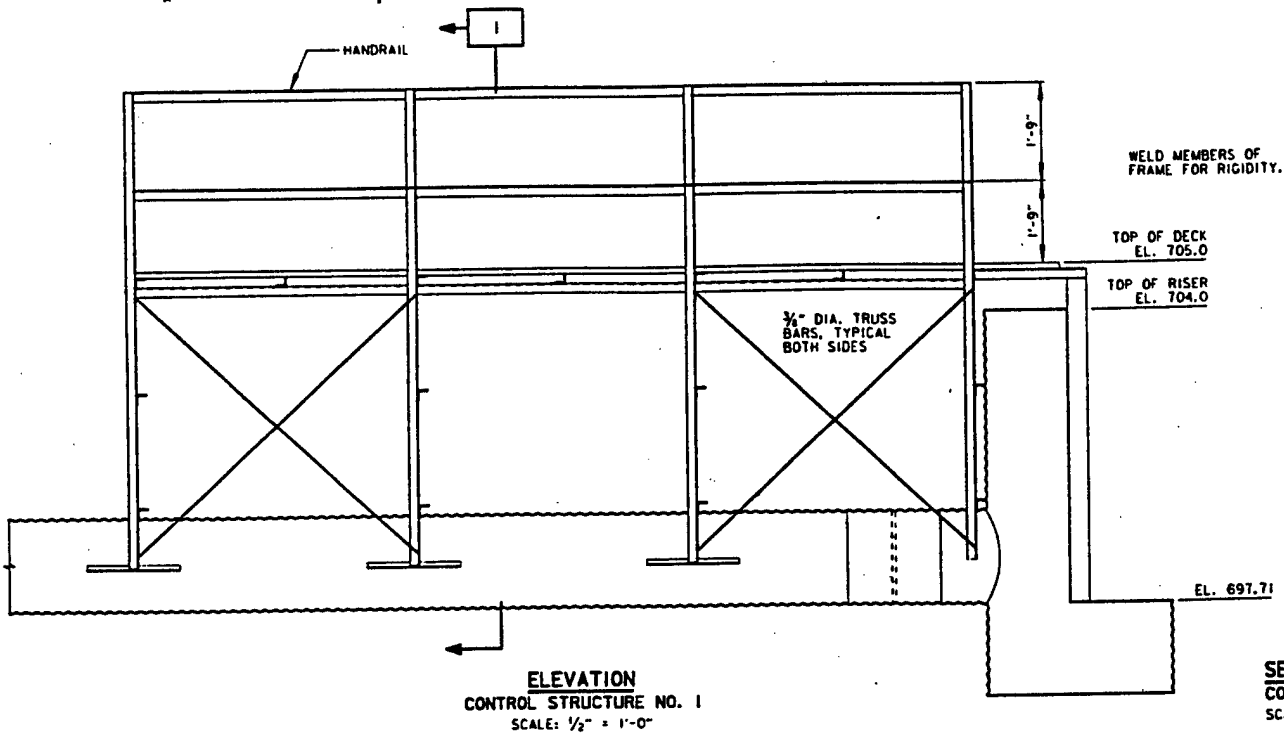




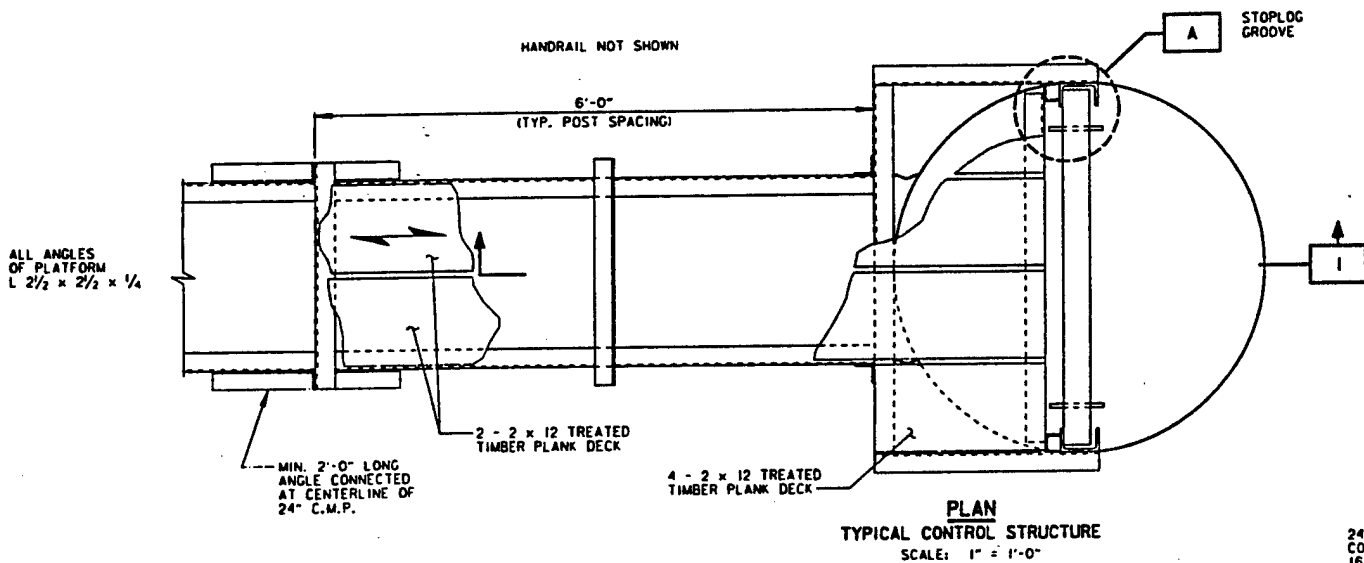
#### NOTES:

1. ANNULAR DRAINAGE FILL EXTENDS FROM THE POINT DIRECTLY UNDER THE EDGE OF THE TOP OF LEVEE TO THE LEVEE TOE OR TO ITS INTERSECTION WITH SCOUR PROTECTION
2. ACCESS PLATFORMS TO CONTROL STRUCTURES NOT SHOWN ON THIS DRAWING. SEE DRAWING 5/239.

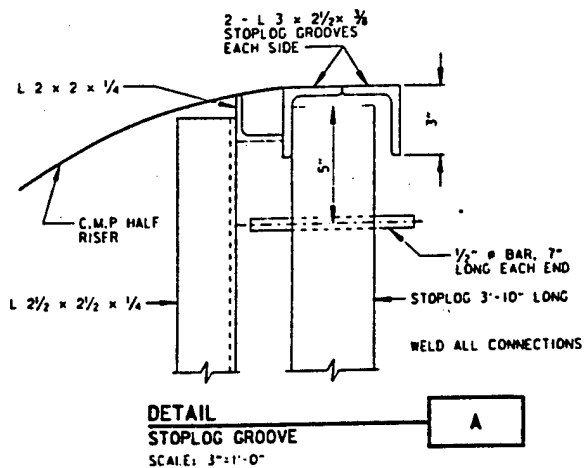
SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA MOIST SOIL UNIT AND CHASKA LAKE CONTROL STRUCTURES PROFILES</p>			
ED-0	DESIGNED:	MAMB TLJ			
	CHECKED:				
	DRAWN:	LKT			
	DESIGNED:				
ED-0	CHECKED:				
DATE: MARCH 10, 1993		SPEC NO:		CAD FILE NAME: MCO4RMSUJ.DGN	DRAWING NUMBER: M34-CH-R-5/238
				SHT 7	OF 9



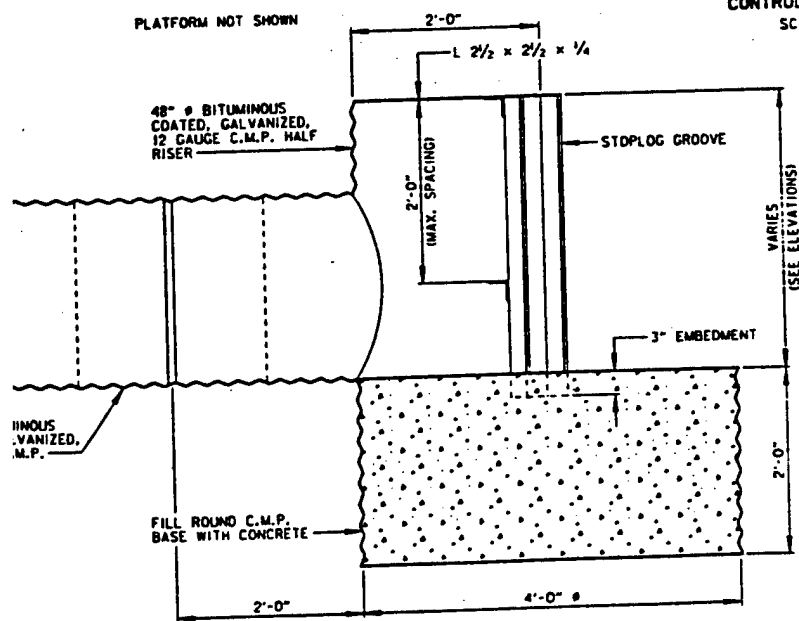
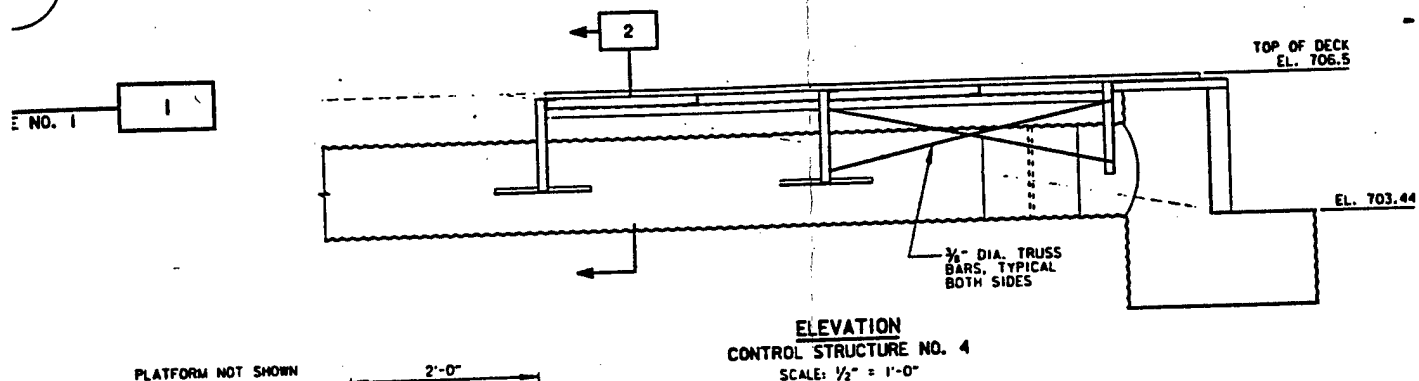
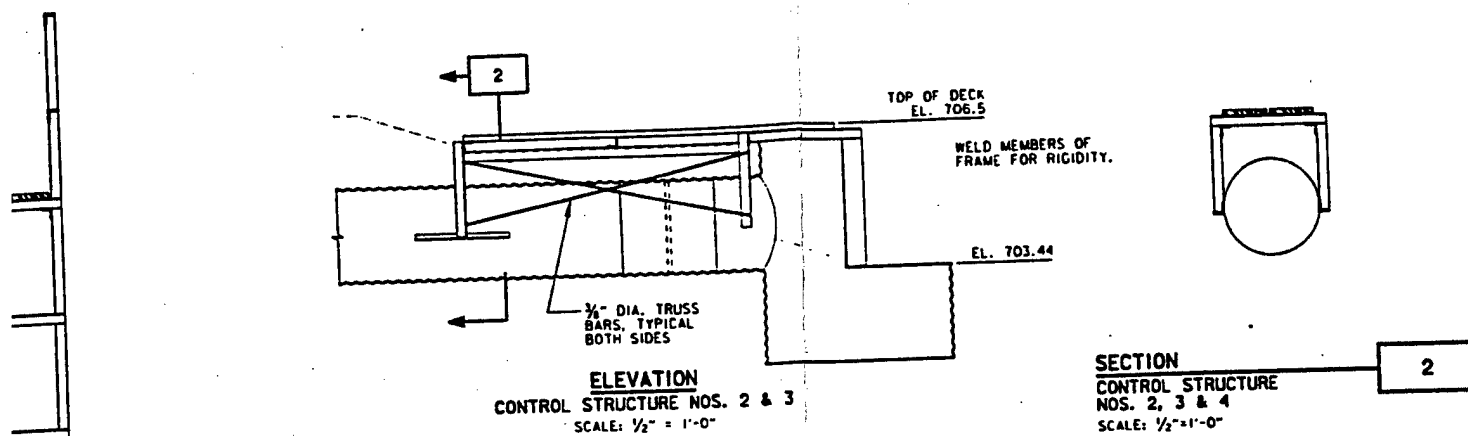
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 CONTROL STRUCTURE  
 SCALE: 1/2" = 1'-0"



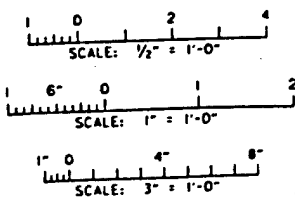
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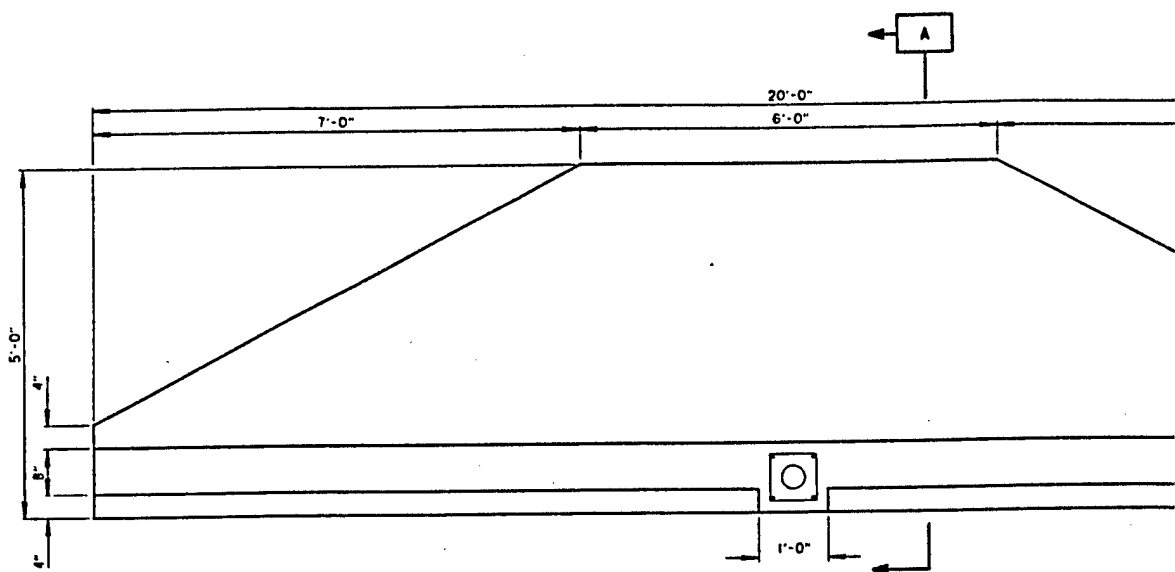
CIVIL ENG  
 HYD  
 HYDR  
 GEOTECH  
 ENV ENG  
 MEA



**SECTION**  
TYPICAL CONTROL STRUCTURE  
SCALE: 1" = 1'-0"

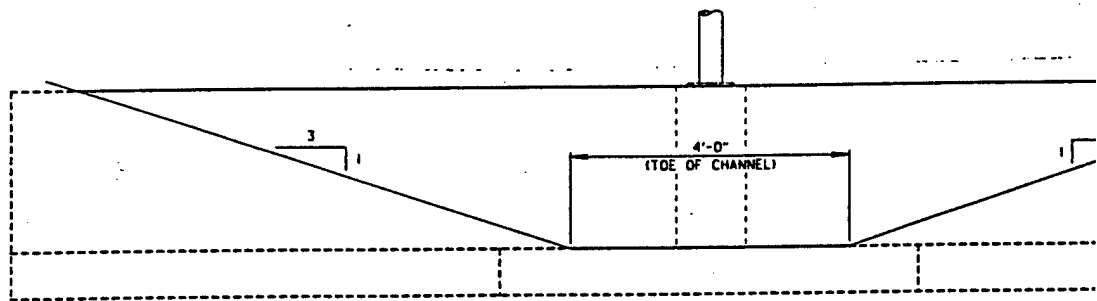


SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 MOIST SOIL UNIT &amp; CHASKA LAKE FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA</p>			
DESIGNED: NRH		CHASKA PROJECT			
CHECKED:		MOIST SOIL UNIT			
DRAWN: LRT		CONTROL STRUCTURES & PLATFORMS			
DESIGNED: XXX/XXX		PLAN, ELEVATIONS, SECTIONS & DETAIL			
CHECKED:		CAD FILE NAME: CHASMSU1.DGN	DRAWING NUMBER:	SHT 8	
DATE: 03-11-93		SPEC NO:	M34-CH-R-5/239	OF 9	



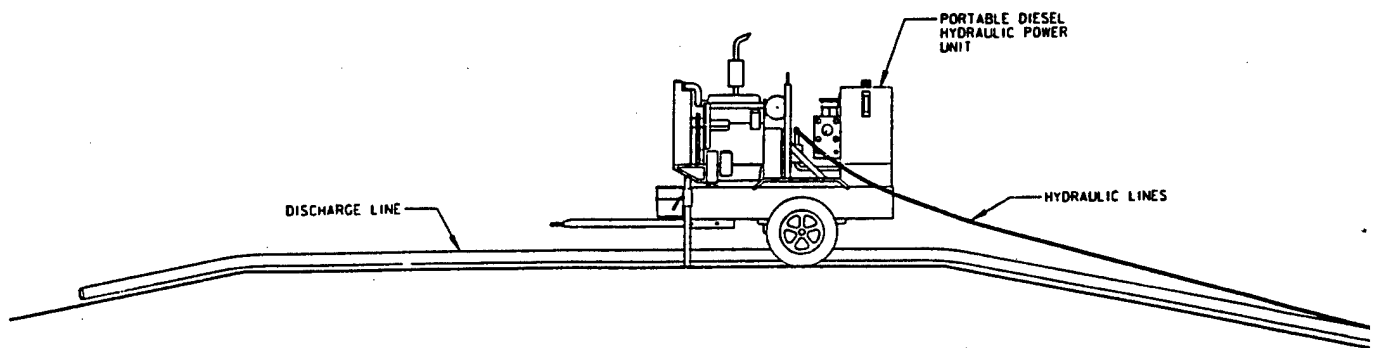
**PLAN**  
**CONCRETE WALL AND CRANE BASE**  
 SCALE:  $\frac{3}{4}$ " = 1'-0"

EXISTING GROUND



**ELEVATION**  
**CONCRETE WALL AND CRANE BASE**  
 SCALE:  $\frac{3}{4}$ " = 1'-0"

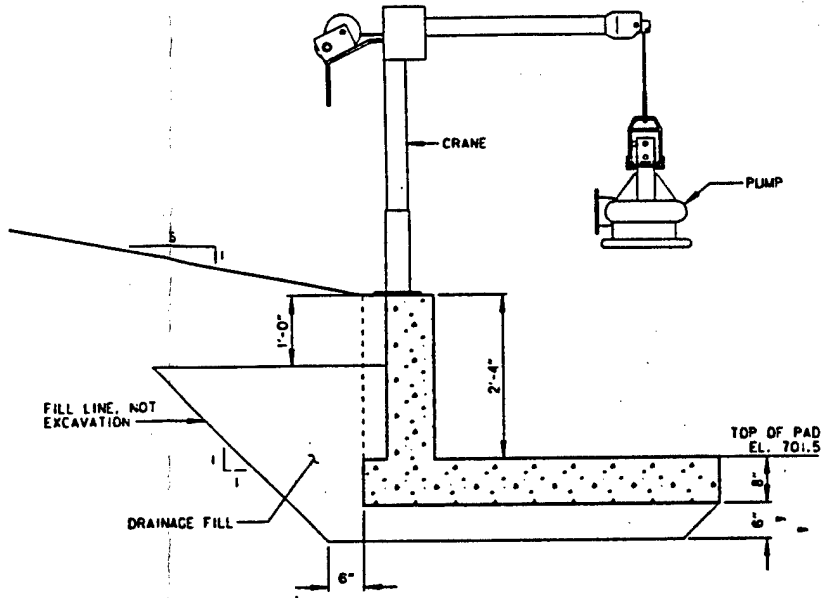
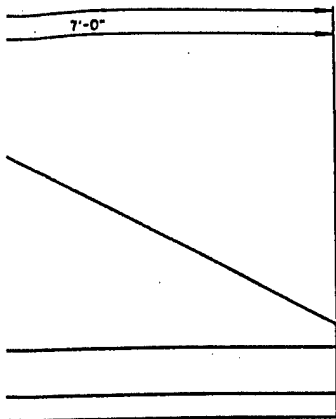
- GEN ENG
- HYD
- HYDR
- GEOTECH
- STR ENG
- MEA



**CHASKA LAKE PUMPING DIAGRAM**

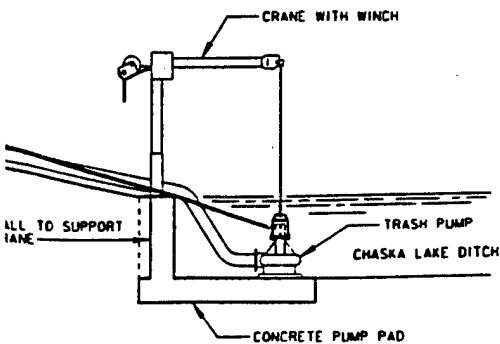
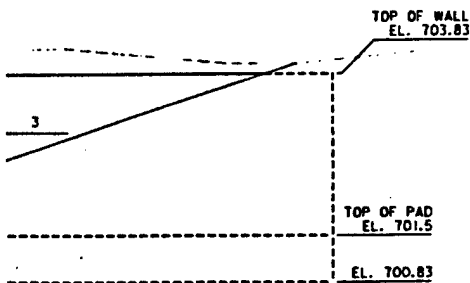
SCALE: NONE

WALI  
 CRAI



SECTION  
INLET WALL  
SCALE:  $\frac{3}{4}$ " = 1'-0"

A



1 6" 0 1 2  
SCALE:  $\frac{3}{4}$ " = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPRO
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 - SUPPLEMENT NO. 1 MOIST SOIL UNIT AND CHASKA LAKE FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA</p>	
<p>DESIGNED: NRH</p>		<p>MOIST SOIL UNIT</p>	
<p>CHECKED:</p>		<p>INLET PORTABLE PUMP, CRANE &amp; WALL</p>	
<p>DRAWN: LKT</p>		<p>PLAN, ELEVATION, SECTION &amp; DIAGRAM</p>	
<p>DESIGNED: XXX/XXX</p>		<p>CAD FILE NAME: CHASMSU2.DGN</p>	
<p>CHECKED:</p>		<p>DRAWING NUMBER:</p>	
<p>DATE: 05-13-93</p>		<p>SHT 9</p>	
<p>SPEC NO:</p>		<p>OF 9</p>	
<p>M34-CH-R-5/240</p>			



DEPARTMENT OF THE ARMY

U.S. Army Corps of Engineers  
WASHINGTON, D.C. 20314-1000

REPLY TO  
ATTENTION OF:

21 OCT 1991

CECW-EP-E

MEMORANDUM FOR Commander North Central Division,  
ATTN: CENCD-PD-ED-TM

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

1. Reference CENCD-PE-ED-TM, 2nd endorsement with enclosures,  
subject as above, dated 12 Aug 91.

2. The DM has been reviewed and the following comments are  
provided for appropriate action.

a. Page 5, Section 21. Although environmental  
documentation is completed, it was done prior to current HTW  
awareness. Suggest that CENCS formally document their  
evaluation of the HTW potential of this project for any future  
reference. Such an effort would be in keeping with CECW-PO  
guidance "Draft Guidance on Hazardous and Toxic Wastes (HTW) for  
Civil Works Studies and Projects," dated 30 Jul 90. An  
assessment appropriate for a reconnaissance study should be  
conducted as a first priority, and included in the response to  
these comments and bound in front of the DM in accordance with  
EC 1110-2-268, paragraph C-6.

b. Page 7, Real Estate Requirements.

(1) General. A more complete section for real estate  
should have been prepared. Currently, real estate information  
is not very detailed and much of the information is scattered  
through the various sections, making review difficult. Assuming  
a Real Estate DM is not scheduled, an effort should be made to  
pull this information together in a more understandable section  
within this DM.

(2) Page 7, Paragraph 30.

(a) This paragraph states that "...the City will  
provide...all real estate interest, to include borrow and  
disposal areas,... Elsewhere in the report, it states that  
borrow and disposal will be from/at various commercial sites.  
If real estate is required for disposal of spoil material,  
indicate acreage and estimated value of such real estate at an  
appropriate location in the real estate section. If the  
commercial sites will be sufficient, indicate the estimated  
value for LERRD crediting purposes.

(b) An Attorney's Opinion of Compensability for each  
relocation is required. Clarify in this report if this has  
been accomplished.



CECW-EP-E

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

c. Page 12, Table 1. The report shows a total project benefit cost ratio of 0.72 based on the latest approved economic analysis in the February 1984 GDM (October 1983 price levels). Since the project is considered a continuing PED activity, the economic analysis must be updated every two years per EC 11-8-2, para. 8d, and ER 1105-2-100, para. 5-18b. As such, the current total project benefit cost ratio should be revised based on updated benefits. The Remaining Benefits- Remaining Costs Ratio should also be presented since it is required in support of the budget request (EC 11-8-2, para. B-2.13d.)

d. Page 13, Paragraph 43. The cost estimate for O&M is provided here without any detailed breakdown elsewhere in the report. Identification of the major elements, quantities and total cost per item should be included as a minimum. This permits the reviewer to see the same level of information which should have been passed on the local sponsor for their budgetary planning purposes.

e. Mechanical.

(1) Page E-8. In calculating the total head, Paragraph a, page 12, of EM 1110-2-3105 should be followed. Arrangement c of Sketch No. 1 on page 13 of the EM is similar to the type used in this DM. Static Head calculated in accordance with that sketch should be  $(725.9 - 698) = 27.9$  feet instead of the 31 feet shown.

(2) Care should be given in the design of the approach and forebay for the pumping station due to the fact that the storm water has a 90° turn before entering the forebay area. ETL 1110-2-313 should be used as guidance for the design.

(3) Design analysis covering pump design/selection and pump station configuration should be included for review.

f. Electrical.

(1) A one line diagram of the electrical distribution system should be provided as a part of this DM. A schematic diagram of the reduced voltage starting system for the submersible pump motors should also be provided.

CECW-EP-E

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

(2) Appendix E, Paragraph 30. This paragraph specifies that the submersible pump motors shall be capable of operating continuously in a totally, partially, or non-submerged conditions. These motors are not normally designed to operate in a non-submerged condition; therefore it is questionable whether motors can be procured that will meet this requirement. Even the operation of these motors in a partially submerged condition is questionable and should be avoided. To operate the motor in a partially or non-submerged condition would require that the float switches be by-passed. The motor would then be shut-down by the temperature sensors specified in paragraph 32(13). This requirement should be verified and its use should be fully justified.

(3) Load demand and short circuit calculations have been provided; however, it does not appear that voltage drop calculations have been made. These calculation should be added to the electrical calculations.

g. Cost estimates are reported differently in this DM and in various other documents being processed concurrently. For example, the total cost of Stage 4 is shown as \$11,817,000 on page G-3 of the DM; as \$10,981,000 in the most recent PES, Part IV; and as \$10,955,000 in the just processed SACCR. In addition, the Total Project Cost is shown as \$38,700,000 in the Executive Summary of DM #2, and in the PES as \$35,500,000 for the Current Approved Estimate and as \$41,200,000 for the Forecast Estimate. Steps should be taken to assure consistency among these various documents.

3. Respond as to action taken on these comments within 60 days. The Engineering Division POC is Mike Smith, CECW-EP-E, (202) 272-8951.

FOR THE DIRECTOR OF CIVIL WORKS:

Encl wd



JOHN A. MCPHERSON  
Acting Chief, Engineering Division  
Directorate of Civil Works

CENCD-PE-ED-TM (CECW-EP-E/21 Oct 91) (1110-2-1150a) 1st End  
Mr. Ordonez/(312)-353-9057  
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

Commander, North Central Division, U.S. Army Corps of Engineers,  
114 N. Canal Street, Chicago, IL 60606-7205 07 NOV 1991

FOR Commander, St. Paul District, ATTN: CENCS-ED-M

1. Review comments from CECW-EP-E are forwarded for your action.  
Responses to comments should be provided to CENCD-PE-ED-TM NLT  
15 Dec 91.

2. The HQ, NCD, POC is Mr. Jose Ordonez, (312) 353-9057.

FOR THE COMMANDER:

Encl  
nc

*for* *John P. D'Aniello*  
JOHN P. D'ANIELLO, P.E.  
Director, Engineering and  
Planning Directorate

*Rec'd 13 Nov 91*  
*JON*

CENCS-ED-M (1110) (CECW-EP-E/21 Oct 91) 2nd End

Mr. Heyerman/kk/(612) 220-0432

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design  
Memorandum No. 2, Stage 4, Minnesota River

FOR Commander, North Central Division, ATTN: CENCD-PE-ED-TM, River Center  
Building, 111 North Canal Street, Chicago, Illinois 60606-7205

Commander, St. Paul District, ATTN: CENCS-ED-M, 180 Kellogg Blvd. E., Room  
1421. St. Paul, Minnesota 55101-1479 12 DEC 1991

1. Responses to comments contained in the 1st Endorsement follow with reference to comment number.

2. Comment 2.a. Potential contaminated sites have not been identified in this stage through geotechnical investigations or through discussions with the City of Chaska. An environmental site history assessment has been conducted. The available evidence shows that the portion of Chaska along the levee has never been developed for other than residential use. No businesses, either retail or manufacturing, were located along the levee (within at least one city block) since Chaska was settled in the 1850's. Therefore, it is highly unlikely that any hazardous/toxic sites exist within Stage 4 of the Chaska Flood Control project.

3. Comment 2.b. (1). The level of detail for real estate requirements for this stage of work is appropriate. The District has worked closely with the City of Chaska on acquisitions for the completed Chaska Creek diversion. Real estate drawings for this stage of work were provided to the City of Chaska on 23 August 1991, and the city is actively acquiring necessary real estate interests.

4. Comment 2.b. (2)(a). Real estate interest is not required in the commercial disposal area proposed for this project (page F-3). The major commercial site for impervious fill will be leased by the City of Chaska. The estimated value for LERRD crediting is \$176,000 (page G-7).

5. Comment 2.b. (2)(b) - It is CENCS-RE opinion that utility relocations listed in Table F-1 and road relocations listed on page 4, paragraph 15, are compensable and part of the Chaska Flood Control project. A formal Attorney's Opinion of Compensability for the relocations has not been accomplished to date. An Attorney's Opinion will be completed prior to contract advertising.

6. Comment 2.c. This project is currently under construction and is no longer classified as PED. Guidance pertaining to PED should not be imposed at this stage. Since there is an existing LCA committing the COE to this project and since significant expenditures have already been made, the overall project BCR is no longer the major issue. The pertinent cost ratio is the Remaining Benefits-Remaining Costs Ratio, which is 1.3 to 1 at 8 7/8 percent for this project. It should be noted that completed work is not producing its overall intended function of removing the City of Chaska from the threat of flooding

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SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design  
Memorandum No. 2, Stage 4, Minnesota River

and the remaining work is critical to the overall functioning of the project. Therefore, the remaining benefits are the total project benefits and the remaining costs are those related to the remaining work. The 9 July 1991 CECW-P memorandum, Subject: Reporting and Updating Benefit Cost Ratios for Civil Works projects, defines a separable element as having "operational, environmental and economic impacts directly related to, and only associated with the individual project element...Independent hydrologic effects connote a hydrologic and hydraulic independence from the output and benefits of other projects..." It is the Districts opinion that the Chaska Creek diversion does not meet the guidelines as a separable element. Also, no separable elements are identified in the project LCA, which was executed on 12 September 1988.

7. Comment 2.d. The O&M cost estimate for this stage of work is \$30,364 per year and consists of the following major components:

Riprap/Bedding	.....	\$3,882
Pump Station	.....	\$2,750
Pavements	.....	\$7,096
Levee Maintenance	.....	\$6,335
Inspections	.....	\$10,000
Other	.....	\$301

8. Comment 2.e. (1). Static head should be 27.9 feet as indicated in the comment. Total dynamic head would then be 33.5 feet. Operating condition for the pump would be 6,000 gallons per minute at 33.5 feet of total dynamic head.

9. Comment 2.e. (2). Station has been designed to account for the 90 degree turn the water will make.

10. Comment 2.e. (3). Pump design and selection criteria have been provided in Appendix E. Any further information needed beyond that shown should be requested. Station layout analysis is indicated on the attached enclosure 1. Design has followed Hydraulic Institute Standards.

11. Comment 2.f. (1). See the attached enclosure 2.

12. Comment 2.f. (2). The submersible pumps selected are designed to either operate at the centerline of the volute or at the top of volute. Station has been designed so the minimum water level when pumping will be elevation 698.0. This elevation will be above the pump volute and is approximately in the center of the motor. Pump will not overheat under these conditions.

13. Comment 2.f. (3). See the attached enclosure 3.

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SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design  
Memorandum No. 2, Stage 4, Minnesota River

14. Comment 2.g. Cost estimates vary based on timing of reporting requirements, whether E&D and S&A is included, whether the estimate is inflated through construction or indexed to a certain year price level. Consistency is difficult due to the number of various documents and timing of those documents. The PES estimate specifically states it is October 1991 price level and the DM estimate specifically states it is an inflated, fully funded estimate.

FOR THE COMMANDER:

3 Encls

1. Sump dimensions
2. One line, etc.
3. Electrical calcs.

*for Stan Kumpala*  
ROBERT F. POST  
Chief, Engineering Division

CENCS-ED-M (1110) (ED-M/24 Apr 91) 2nd End

Mr. Heyerman/kk/(612) 220-0432

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design  
Memorandum No. 2, Stage 4, Minnesota River

FOR Commander, North Central Division, U.S. Army Corps of Engineers, ATTN:  
CENCD-PE-ED-TM, 111 N. Canal Street, Chicago, Illinois 60606-7206

Commander, U.S. Army Corps of Engineers, 180 Kellogg Blvd. E., Room 1421, St.  
Paul, Minnesota 55101-1479

29 JUL 1991

1. Responses to comments contained in the 1st Endorsement follow with reference to commentor name and number.

2. Korbus 1.

a. Paragraph 15 on page D-3 of the Structural Appendix describes the uplift conditions as given to the Structural Section from the Geotech Section. At the pumping station wall 28' from the berm toe, the uplift head increases to El. 716 from El. 713 at the berm toe. Attachment 1 shows these uplift head elevations through the levee at the pumping station.

b. The uplift head for the pump station was determined in the following manner. The maximum head at the midpoint distance between two adjacent wells was used as the maximum expected landside head. A straight line interpolation between the seepage entrance and the berm toe was then used to determine the uplift pressures at the pump station. A summary of uplift calculations is given in Table 2 of appendix C.

3. Korbus 2. According to appendix B of ER 1110-2-1150 "Engineering After Feasibility Studies", a Design Memorandum does not require structural design computations to develop details for this type structure. Including the area of steel required and identifying reinforcing selected is more detail than necessary for the Design Memorandum. For the convenience of your review, the maximum area of steel required and reinforcing size for the pump station wall design of this DM will be given using the formula on the last line of page D-8. Add the following information at the end of each page of the calculations listed.

Page

D-8:As( $\mu=560$ "k,d=14.5")=.75 sq in/ft max. reinf. req'd.- #8@12"

D-10:As( $\mu=670$ "k,d=20.5")=.62 sq in/ft max. reinf. req'd.- #5@6"

D-13:As( $\mu=397$ "k,d=20.5")=.37 sq in/ft max. reinf. req'd.- #6@12"

D-14:As( $\mu=158$ "k,d=10.5")=.29 sq in/ft max. reinf. req'd.- #5#12

D-16:As( $\mu=783$ "k,d=12.5")=1.26 sq in/18" wide beam max. reinf. req'd. 3-#6

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4. Korbus 3. A revised page D-18 is attached. The different areas of the pump station are labeled along with wall and slab thicknesses. The descriptions of the structural features in the calculations can be identified more plainly on the revised sketch. This should help in your review.

5. Korbus 4. Paragraph 4-7.b of EM 1110-2-3104 refers to the Mechanical EM 1110-2-3105 for discussion of forces on the gate structure induced by gate operation. EM 1110-2-3105 says the components of the sluice gate lifting device (like the stem) shall fail under extreme load before the support. The standard method of sizing sluice gate components in this District is to use a safety factor of 5. This is the way the sluice gate specification is written. Since the components of the gate are designed for this safety factor, the support shall be designed for that safety factor also.

6. Korbus 5. The uplift head for the pump station was determined in the following manner. The maximum head at the midpoint distance between two adjacent wells was used as the maximum expected landside head. A straight line interpolation between the seepage entrance and the berm toe was then used to determine the uplift pressures at the pump station. A summary of uplift calculations is given in Table 2 of appendix C.

7. Korbus 6. A mistake was made in the table on page D-41 of the Structural Appendix for the 72" pipe. The Table should say  $H = 9.92$  ft.,  $W_e = 10,360$  #/ft. and  $D\text{-load} = 1150$  #/1.f./ft. diam. Class III-72" diameter pipe will be adequate for this D-load.

8. Tenke-White 1. Concur. On page G-5, the item Mob & Demob was changed to 16,550 and on page G-6 the manhole subtotal was added. Also a dashed line was added throughout the estimate between the item subtotal and the item's subitems. This resulted in more pages which required a revised Table of Contents and revised pages G-5 through G-24.

9. Tenke-White 2. Concur; Revised page G-8 provided.

10. Tenke-White 3.

a. Concur.

b. The District's Construction Management costs on large projects such as Chaska Stage 2, which is currently under construction, has been running at about 6.1 percent. The 6.5 percent indicated is adequate.

11. Tenke-White 4. Recent analysis by our Cost Engineering Branch indicate engineering costs for projects between \$1,000,000 and \$10,000,000 range from 35 to 15 percent. Interpolation results in 24.4 percent for Chaska Stage 4. Items that tend to increase the Stage 4 rate are:



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SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design Memorandum No. 2, Stage 4, Minnesota River

a. The relatively small pump station requires about the same design effort as a large more expensive pump station.

b. Good design reduces construction cost which in turn increases the engineering rate.

c. Stage 4 is a complex project.

12. Tenke-White 5. A phone conversation with the commentor determined that the 30 account should be the 31 account in the original comment. The District's Construction Management costs on large projects such as Chaska Stage 2, which is currently under construction, has been running at about 6.1 percent. The 6.5 percent indicated is adequate.

13. Tenke-White 6. No response required.

14. Vento 1. As indicated in paragraphs 19 (page B-6) and 24 (page B-7) and shown on Plate 6 of the General Design Memorandum revised in August 1984, the former pumping station location was near Pine Street, adjacent to outlet B.

15. Vento 2. TP 40 and TP 49 are required to obtain rainfall amounts for durations longer than 24 hours. Theoretical rainfall amounts for durations of 24 hours or less for new start projects are obtained using HYDRO-35.

16. Vento 3. Concur. Plate A-12 was not used and should be eliminated from the report. The rainfall amounts presented in table A-1 are the same as presented in table B-1, page B-18 of the General Design Memorandum, revised August 1984. The rainfall-duration curves presented on Plate A-13 are the same curves as presented on Plate B-16 of same reference.

17. Vento 4. Page ii which includes the table of contents for appendix B tables and plates is provided.

18. Vento 5. The estimated peak runoff rate from a SPF at Chaska is about 168,000 cfs. The value of 165,000 indicated in Table 1, page B-3 should be changed to 168,000.

19. Vento 6. The two existing pump stations were constructed about 1951 and are located within the area required for levee and/or berm construction. The pump stations would require extensive and expensive remodeling to meet proposed needs. The existing pumps and motors are old and do not have the required pumping capability or horsepower. The stations are to be demolished and the pumps and motors will be salvaged by the city or construction contractor. Also based on the District's experience, the rehabing of pumps costs about the same as the purchase of a new pump and rehabing does not provide nearly the same useful life.

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20. Vento 7. As indicated on pages G-9 through G-11, the cost of the proposed interceptor pipe is estimated to be about \$583,000 with contingency, and each outlet about \$285,000 with contingency. Therefore, considering that the cost of each outlet structure is about equal to one-half of the cost of the entire length of interceptor pipe, it will not be practical nor economical to increase the number of gravity outlets. Use of the existing outlets in the proposed plan is not practical; because the condition and strength of the existing pipes is unknown, they are extremely small with a relatively high invert elevation, and would require the construction of energy dissipaters at the downstream end.

21. Vento 8. The following is the required size, length, and cost of interceptor pipe based on the recommended plan and on an earlier 1 percent plan investigated:

Pipe Size:	18	24	30	36	42	48	54	60	66	72
Required Length In Ft										
Recommended Plan	190	250	404	404	482	554	394	392	334	336
1 percent Plan	-	590	220	520	940	840	-	550		

The estimated cost of interceptor pipe for the recommended plan is about \$583,000 with contingency. The estimated cost of interceptor pipe for the 1 percent plan investigated appears to be about \$100,000 less than for the recommended plan. The estimated maximum interior pond level during a SPS event with the recommended plan is designed to match existing conditions and will be about 710.9 in section 2 and about 712.5 in section 3. The estimated maximum interior pond level during a SPS event with a 1 percent plan, based on a combination of inlet and/or pipe control, will be about 711.7 in section 2 and about 715.3 in section 3. Based on the elevation-damage curves presented on Plate A-7, the resulting damages would be about \$420,000 for existing conditions and the recommended plan and about \$1,040,000 with the 1 percent plan. With the recommended plan the area inundated by a SPS event would cover about 6.2 acres in section 2 and about 7.8 acres in section 3, or a total of about 14 acres, generally located along the proposed line of protection and generally within the project right-of-way. With a 1 percent plan, the area inundated by a SPS event would cover about 9.3 acres in section 2 and about 16 acres in section 3, or a total of about 25.3 acres. The additional 11.3 acres required with a 1 percent plan would extend into residential areas and result in about \$620,000 of additional flood damage. It is felt that the approximate \$100,000 in additional cost is justified to prevent the inundation of about 11.3 acres of residential property and the possible \$620,000 in additional damages. Also, the additional 11.3 acres would likely require flooding easements.

22. Simpson 1. Concur. This will be required by the specification.

CENCS-ED-M (1110)

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22. Simpson 2. Do not concur. The determination of embankment saturation should consider the melting of snow and/or ice, rainfall, pervious seams in the existing embankment and pervious seams in the foundation soils as well as the flood duration. Also, at Chaska, the flood duration can be extended several days by backup from Mississippi River flooding. Considering the minimal time required to analyze the two cases and the fact that the embankment slopes required by either maintenance considerations or other stability cases will usually provide adequate factors of safety for the two cases in question, it is generally much quicker (and therefore more cost-effective) to simply assume embankment saturation, analyze the two cases and show that required factors of safety are met rather than attempt to evaluate all factors that may contribute to embankment saturation and then argue the applicability of the cases and/or the validity of the evaluation.

23. Simpson 3. Do not concur. The soil strength after consolidation has already been selected somewhere between the Q-strength and R-strength. The soil layers 5 & 6 are consolidated from the first stage fill and will probably be 90 percent to 100 percent consolidated before additional loads are applied. The strengths for these layers were obtained from the R-strength test information using the normal stress from the first stage fill and so they essentially have a phi value in them.

24. Simpson 4. Concur. The strength and stress/strain characteristics of the embankment soils are not known at this time but will be determined for preparation of the plans and specifications. At that time stability analyses will be redone with appropriate stress/strain considerations and with the higher foundation strengths mentioned in paragraph 22 on page C-6.

25. Simpson 5. Concur. The results are correct. The attached Table A shows the Q-strength data for the soft foundation layer. The data does not show any definitive trend of increasing strength with increasing depth. Agree that the "average" foundation soil strength is likely 400 psf.; however, design strength was selected at the one-third point in accordance with EM 1110-2-1902.

26. Simpson 6. Do not concur. The crack depth was determined from the formula on page 24 of the "USER'S GUIDE: UTEXAS2 SLOPE-STABILITY PACKAGE, Volume II: Theory". The crack depth used in the analysis is about one-half that calculated from the formula on page 43 of the Contract Report. Note that if  $\phi=0$ , the crack depth formula from the USER'S GUIDE is  $2*c/(\gamma*F)$  or one-half the  $4*c/(\gamma*F)$  formula given on page 43 of the Contract Report. The USER'S GUIDE formula is considered the correct formula for determining the depth of tension cracks. If crack depths of 7.5 to 10 feet were obtained using the  $4*c/(\gamma*F)$  formula, it appears the 300 to 400 psf strength of the soft foundation soil must have been mistakenly used in the calculation instead of the 1200 psf strength of the embankment. Although a shallower-depth crack and a higher foundation strength would obviously result in a higher factor of safety, they are not considered appropriate for the analysis.

CENCS-ED-M (1110)

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design Memorandum No. 2, Stage 4, Minnesota River

27. Simpson 7. Concur in part, Do not concur in part. NCS computations are not for a "deeper than usual crack analysis"-see response to comment 6. Note that the end of construction factor of safety of 1.0+ given in the report is for the end of the first stage of construction. At that time a factor of safety of 1.3 is not required since the new levee has not yet replaced the existing emergency levee as the main line of protection. As shown in the report, the end of construction factor of safety exceeds the required 1.3 at the end of the second (final) stage of levee construction when the new levee could become the main line of protection, if necessary, by filling the East Creek opening and pumping East Creek flow over the new levee. Strength increase from consolidation is needed for both second stage levee construction and to increase factors of safety to required values when second stage construction is complete. A discussion of the time rate of consolidation, with at least a sample computation, should have been included in the report but was unfortunately overlooked during final report preparation. The attached Table B provides a summary of time/settlement data for first stage loading at a typical levee section. Ultimate settlements are shown in the first row for 20 foot increments across the section. Remaining rows show the amount of settlement at the end of the number of years shown in the left-most column. At the levee centerline ( $x=0$ ) the data show 60 percent of the ultimate settlement will occur in about 5 years and that about 20 years would be required to reach 95 percent consolidation. Consequently, consolidation will not occur in a short time period unless drainage of the compressible layer is significantly enhanced.

28. Simpson 8. Concur. Note that the existing embankment on the east side of Courthouse Lake has a top elevation of 716+ which is about ten feet lower than the new levee. Also the existing embankment was constructed on the edge of an old clay mine pit (Courthouse Lake) where the foundation soils may not have been as poor as those encountered where the new levee is being constructed. The existing levee was also raised as less frequent floods occurred, resulting in an actual (though unplanned) staged construction.

29. Simpson 9. Concur. Because of time constraints only the worst case condition was looked at for this reach. Further analyses will be done for plans and specifications to determine if the extent of the wick drains can be reduced or if there are locations where increased spacing is possible and economically practical. However, decreasing the thickness of the clays to 20 feet does not by itself assure rapid consolidation. See the response to comment 7 in regard to the time rate of settlement.

30. Simpson 10. Do not concur. Using UTEXAS2 in accordance with it's User's Guide will probably not give an increased factor of safety with increased levee material strength. Also, the strength of the levee fill has not been determined and may be lower than what is used in the report. When the strength of the borrow material is obtained additional analyses of slope stability will be performed to verify final levee design.

CENCS-ED-M (1110)

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design  
Memorandum No. 2, Stage 4, Minnesota River

31. Simpson 11. Do not concur. The current design complies with COE slope stability criteria at the completion of levee construction. It would not be desirable for the construction contract to be complete and not have the levee comply with COE slope stability criteria. Note that the end of construction factor of safety for the first stage is just slightly over 1.0. However, at the completion of the second stage (when the levee could easily become the main line of protection) the end of construction factor of safety is 1.3 in accordance with criteria.

32. Simpson 12. Do not concur. A controlled sequence of placement, a layer of granular material between the subgrade and new levee fill, stability berms, and a two-stage construction process are used in the current design. Without the wick drains consolidation will not occur in a reasonable period of time. The effect of levee material strength will be reevaluated when testing of the material is completed. All other alternatives mentioned, except for the reduced cracking depth, have previously been considered. See the response to comment 6 regarding crack depth computations.

33. Simpson 13. Concur. CSETT input is given in attached Table C. A summary of time/settlement computations for first stage construction is given in attached Table B and discussed in the response to comment 7.

34. Simpson 14. Do not concur. Except for the minimum berm width, berm design in the report is in accordance with EM 1110-2-1913. The suggested alternative (a) design procedure is not included in the EM as an OCE-approved berm design and the alternative would provide a less costly berm only because it provides a lower margin of safety. Where relief wells are used the additional real estate costs and reduced benefits which would be required if the berms were used still appear to leave relief wells as the least costly alternative for controlling uplift pressures. The suggested alternative (b) (pervious toe trench and horizontal drain) as shown on Figure 5-4 of EM 1110-2-1913 is not considered a practical, low cost alternative at Chaska because of the large quantity of seepage through the deep pervious zone along the river and because, in some areas, removal of much of the existing levee would be required to construct the pervious trench and horizontal drain. The current design minimizes excavation and replacement of the existing levee in order to minimize cost. Suggested alternative (c) was not considered because of the large trench depth that would be required and the high probability that such a trench would significantly interfere with normal groundwater discharges to the river during non-flood periods.

35. Simpson 15. Concur. In general, construction of all structures for the project results in a net unloading of the soil directly underneath the structure. Because of this net unloading, bearing capacity calculations have not been made. The two structures where settlement may be a problem will need to have analyses completed during plans and specification. The pipes of the

CENCS-ED-M (1110)

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota Design  
Memorandum No. 2, Stage 4, Minnesota River

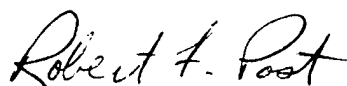
gravity outlet placed upstream of Highway 41 will be checked to determine if banded joints will be required because of the additional fill being placed landward of the levee centerline. The existing pipe exiting on the south side of the sewage treatment plant will need to be reanalyzed because of the additional fill being placed in that location.

36. Simpson 16. Concur in part, Do not concur in part. Discounting the borings taken through existing fill because of consolidation which would have taken place, there are 11 borings of which 5 borings show soft materials to approximately elevation 675. Four additional borings show soft material to approximately elevation 685 and the remaining two borings show soft material to between elevations 690 and 695. The soil profile used for design assumed soft material down to elevation 675 at some distance from either station 7+50 or the existing embankment on the east side of Courthouse Lake. See the response to comment 9 regarding the wick drain design and additional analyses required to refine the design. Design refinements will be delayed until borrow material strengths become available.

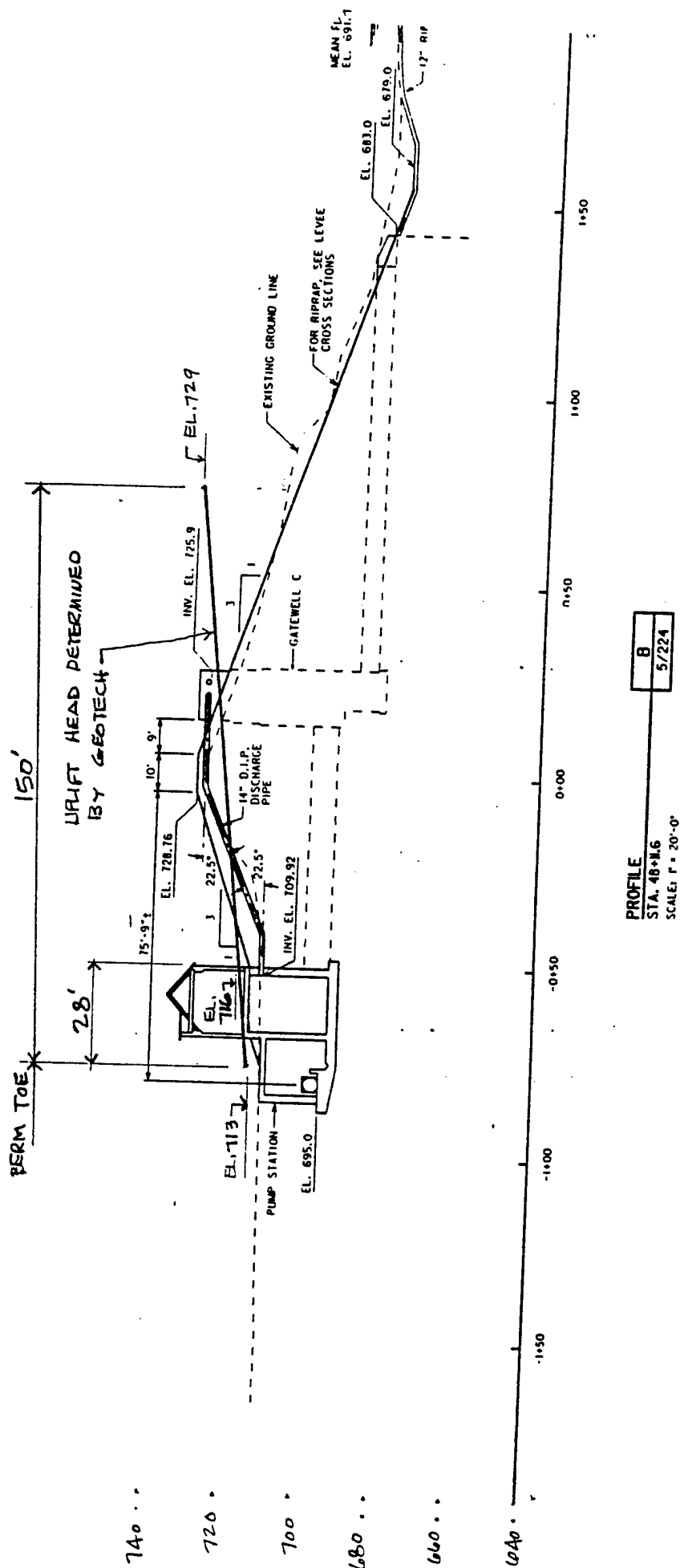
37. Simpson 17. Do not concur. Computations for wick drain spacing, etc. should have been included in the report but were unfortunately overlooked during final report preparation. See attached Table D for computations for the wick drain design shown in the report. The wick drains can not be eliminated unless the second stage construction can be delayed several years (see response to comment 7 regarding time rate of consolidation). Alternatives to wick drains were considered as described in paragraphs 25.a. through 25.c. on page C-7. Also note that the current design includes a drainage layer between the embankment and the foundation. For the suggested sandwich drains to be acceptable, the vertical sand drains described in paragraph 25.c. on page C-7 would have to be added. The wick drains are considered an economical, easily installed alternative to the vertical sand drains. A pervious toe trench and horizontal drain is not considered an acceptable alternative to relief wells at Chaska (see response to comment 14 regarding the suggested alternative).

FOR THE COMMANDER:

Encl  
Appendix G- Revised Table  
of Contents plus pages G-5 thru G-24  
Attachment 1, Uplifthead at pump  
station  
Revised page D-18  
New page ii of appendix B  
Tables A, B, C, and D



ROBERT F. POST  
Chief, Engineering Division



UPLIFT HEAD THROUGH  
LEVEE AT PUMPING STATION

Table A  
Summary of soil strengths  
East of Courthouse Lake  
Soil layer #1

BORING	SAMPLE ELEV.	SPT	CLASS	LL	PL	Wc %	e	GAMMAd (pcf)	Gs	phi (degrees & tsf)	q c
89 - 130	700.1	3	CH	63	33	49.9	1.23	72.0	2.57	0	0.15
83 - 63	698.1	3 TO 10	MH	57	32	62.7	1.61	63.9	2.60	0	0.15
83 - 62	698	3	CH	80	29	53.4	1.44	68.2	2.67	0	0.15
88 - 102	698	4	CH	50	19	36.0	1.00	84.5	2.70	0	0.25
89 - 119	697.8	2	CH	73	28	41.6	1.15	87.9	2.70	0	0.20
88 - 103	695.8	3	CH	69	24	48.0	1.30	72.5	2.67	0	0.15
82 - 41	694.85	2	OH	86	39	69.3	1.74	58.4	2.56	0	0.10
83 - 62	694.15	2	CL	31	14	36.1	0.93	86.1	2.66	0	0.20
89 - 130	694.1	2	CL	41	14	33.4	0.87	88.6	2.65	0	0.10
89 - 126	694	1	CH	64	49	40.8	1.06	81.2	2.66	0	0.10
83 - 63	690.1	4	OH	182	93	169.5	3.64	31.1	2.25	0	0.18
82 - 51	689.8	4	CH	116	31	67.0	1.68	58.7	2.51	0	0.25
82 - 41	689.7	2 TO 5	CH	81	32	74.0	1.93	55.7	2.60	0	0.10
89 - 119	688.8	1	CH	68	26	53.7	1.42	69.7	2.70	0	0.10
88 - 103	685.8	2	CH	56	23	40.7	1.09	80.4	2.69	0	0.30
89 - 126	684	2	CH	67	23	50.2	1.35	71.4	2.69	0	0.20
89 - 119	682.8	3	CH	69	23	44.4	1.21	75.9	2.69	0	0.30
Average						57.1	1.4	70.9	2.6	0.0	0.17



Table B  
Summary time/settlement data  
East of Courthouse Lake  
First stage of construction

PROGRAM CSETT - VERTICAL STRESS INDUCTION AND SETTLEMENT PROGRAM

II. OUTPUT SUMMARY.

1. TITLE- FILE: csett-2.b \*\* AVERAGE VALUES USED FOR ALL INPUT \*\*

2. SUMMARY OF TIME SETTLEMENT DATA.

PLANE OF INTEREST: XRIGHT= -120.0  
XLEFT= 120.0  
DELX= 20.0

TIME (YR)	X=-120.0	X=-100.0	X= -80.0	X= -60.0	X= -40.0	X= -20.0
1-----						
ULT.	0.120	1.202	2.206	2.643	2.683	2.691
0.25	0.016	0.162	0.298	0.356	0.362	0.362
0.50	0.022	0.230	0.421	0.504	0.513	0.513
1.00	0.032	0.324	0.594	0.714	0.725	0.726
5.00	0.073	0.722	1.321	1.585	1.608	1.612
10.00	0.097	0.964	1.771	2.118	2.152	2.157
20.00	0.113	1.143	2.098	2.514	2.555	2.561
40.00	0.120	1.200	2.198	2.637	2.677	2.682
78.55	0.120	1.202	2.206	2.643	2.683	2.691

TIME (YR)	X= 0.0	X= 20.0	X= 40.0	X= 60.0	X= 80.0	X= 100.0
1-----						
ULT.	2.693	2.691	2.683	2.643	2.206	1.202
0.25	0.363	0.362	0.362	0.356	0.298	0.162
0.50	0.513	0.513	0.513	0.504	0.421	0.230
1.00	0.727	0.726	0.725	0.714	0.594	0.324
5.00	1.613	1.612	1.608	1.585	1.321	0.722
10.00	2.160	2.157	2.152	2.118	1.771	0.964
20.00	2.561	2.561	2.555	2.514	2.098	1.143
40.00	2.683	2.682	2.677	2.637	2.198	1.200
78.55	2.693	2.691	2.683	2.643	2.206	1.202

TIME (YR)	X= 120.0
1-----	
ULT.	0.120
0.25	0.016
0.50	0.022
1.00	0.032
5.00	0.073
10.00	0.097
20.00	0.113
40.00	0.120
78.55	0.120

Table C  
Input data for:  
Summary time/settlement data  
East of Courthouse Lake  
First stage of construction

```

010 TITLE
020 FILE: csett-2.b ** AVERAGE VALUES USED FOR ALL INPUT **
030 ZDSO 1 6 0.0 0.0 119.0
040 -9999. 702.0 -113.0 702.0 -68.0 717.0 68.0 717.0 113 702.0
050 9999. 702.0
080 SOIL 1 702.0 s 110.8 0.065 38.61 0.32
090 INDE .416 221.6 1.15
120 SOIL 2 698 C 48.4 0.065 38.61 0.32
130 INDE .416 636.8 1.15
160 SOIL 3 690 C 40.6 0.068 20.93 0.32
170 INDE .568 911.6 1.61
180 SOIL 4 686 C 46.2 0.067 18.64 0.32
190 INDE .430 1142.6 1.29
200 SOIL 5 676 N 64.4
240 BOUS 40
250 TMS .25 .5 1 5 10 20 40 78.55
260 OUTP -120 120 20
270 END

```

Table D  
 "Wick" drain calculations  
 East of Courthouse Lake  
 Design Cv exceeded by two-thirds of the test results

Designing with Geosynthetics  
 Robert M. Koener  
 Prentice Hall, 1988

6.4.2. Designing with geocomposites  
 Designing locations of "wick" drains  
 pg. 566

eq. 6.6  $t = ((D^2)/(8 \cdot Ch)) * [((\ln(D/d))/(1 - (d/D)^2)) - ((3 - (d/D)^2)/4)] * (\ln(1/(1-U)))$

Ch(ft<sup>2</sup>/day)      0.07  
 Ch/Cv            2  
 Cv(ft<sup>2</sup>/day)      0.035

Design spacing using AMERDRAIN 407 soil drainage wick

fictitious "d" =  $(2 * l + 2 * w) / \pi$   
 d(ft)            0.21884  
 wick(diameter, "d") 2.62606  
 length(in)       0.125  
 width(in)        4

						spacing pattern	
						square	triangular
						(ft)	(ft)
t(days)	* 73.8123	202.022	245.199	319.011	490.398		
D(ft)	* 5	5	5	5	5	4.4	4.8
Ch(ft <sup>2</sup> /day)	* 0.07	0.07	0.07	0.07	0.07		
d(ft)	* 0.21884	0.21884	0.21884	0.21884	0.21884		
U	* 0.5	0.85	0.9	0.95	0.99		

Ch(ft<sup>2</sup>/day)      0.105  
 Ch/Cv            3  
 Cv(ft<sup>2</sup>/day)      0.035

						spacing pattern	
						square	triangular
						(ft)	(ft)
t(days)	* 49.2082	134.681	163.466	212.674	326.932		
D(ft)	* 5	5	5	5	5	4.4	4.8
Ch(ft <sup>2</sup> /day)	* 0.105	0.105	0.105	0.105	0.105		
d(ft)	* 0.21884	0.21884	0.21884	0.21884	0.21884		
U	* 0.5	0.85	0.9	0.95	0.99		

t(days)            \*time for consolidation  
 D(ft)            \*the sphere of influence of the strip drain(1.05\*spacing for triangular pattern; 1.13\*spacing for square pattern)  
 Ch(ft<sup>2</sup>/day)       \*the coefficient of consolidation for horizontal flow  
 d(ft)            \*equivalent diameter of the strip drain(circumference/PI)  
 U                \*the average degree of consolidation

File: C:\ARMS\CHAS4DM2.CMT

Printed: Tuesday May 28, 1991 at 10:25:20 a.m.

Project Info: Chaska Stage 4

Design Memo #2

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
1	KORBUS	ED-TT	D-8	GEN STR	
Provide a sketch indicating how the uplift head, 28 feet from the berm toe was calculated.					
2	KORBUS	ED-TT	D-8 TO D-26	GEN STR	
Include in all pump station wall design calculations the area of steel required and identify reinforcing selected. This is important for later review and verification of construction drawings.					
3	KORBUS	ED-TT	D-8 TO D-26	GEN STR	
Provide a design sketch indicating structural features (walls and slabs) for which design calculations have been presented together with reinforcing to be provided. In the absence of such a sketch, it is difficult to readily identify the applicable wall or slab to be designed.					
4	KORBUS	ED-TT	D-17	GEN STR	
Identify paragraph from EM 1110-2-3104 stipulating a safety factor of 5.0 for gate operator lifting force on forebay slab.					
5	KORBUS	ED-TT	D-24	GEN STR	
Provide sketch indicating how uplift at berm toe (elev. 713 was calculated).					
6	KORBUS	ED-TT	D-41	GEN STR	
Provide rationale for using Class III pipe for 72" RCP (D-load = 1590) inasmuch as the apparent D-load limitation for this class of pipe is 1350.					

File: C:\ARMS\CHASKA.CMT

Printed: Tuesday May 28, 1991 at 1:24:36 p.m.

Project Info: Chaska Stage 4 FDM Cost Est.

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
1	TENKE-WHITE	PE-ED-TT	G-3	EST	
Discussed with Mike Osterby (Cost Eng. NCS) that in certain places the summary sheets did not appear to add correctly. The overall cost changes should be slight, however, they should be corrected to avoid problems in the future. Mike indicated that the contingency might be adjusted to arrive at the same bottom line figure. This is acceptable if the changes are small (<\$100,000).					
2	TENKE-WHITE	PE-ED-TT	G-8	EST	
Item 11.0.1 - East Creek has a JOB value of \$2,900. The summary sheet should reflect a better description to indicate what this activity is.					
3	TENKE-WHITE	PE-ED-TT	G-21	EST	
In the future, a more detailed breakdown of construction management activities will be required. A lump sum, one line description will not be acceptable. An appropriate contingency should be included in the contingency column (not included in the unit price). The cost shown also appears to be too low for a project of this type. The NCS should re-evaluate the CM requirements and revise accordingly.					
4	TENKE-WHITE	PE-ED-TT	G-20	EST	
The 30 Account has been presented in sufficient detail. However, it should be noted that the overall engineering cost is approximately 25% of the project's construction cost. This is excessive for a project of this nature.					
5	TENKE-WHITE	PE-ED-TT	G-3	EST	
Discussed this cost estimate with Real Estate and Construction. Real Estate has no problem with the submitted material. Construction agrees with the comment that the amount in the 30 account is insufficient.					
6	TENKE-WHITE	PE-ED-TT	G-3	EST	
Recommend that this cost estimate be approved subject to the above comments.					

File: C:\ARMS\CHASVEN.CMT

Printed: Thursday May 30, 1991 at 8:58:32 a.m.

Project Info: Chaska Stage 4 DM No. 2

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
1	VENTO	ED-WH	PG-1, PA 4	GEN	
"Pine" Street should be Chestnut Street Hwy. 41.					
2	VENTO	ED-WH	PG.A-2, PA 11	GEN	
Question as to whether TP 40 rainfall be used for interior hydrology evaluation.					
3	VENTO	ED-WH	PG.A-15	GEN	TABLE A-1
Point-rainfall-depth frequency curve, table A-1 values page A-15 do not agree entirely with plotted rule curves on Plate A-12; please check plots or correct table.					
4	VENTO	ED-WH	PG.B-	GEN	
Where is table of contents for tables and plates?					
5	VENTO	ED-WH	PG.B-3	GEN	TABLE 1
The SPF for the Minnesota River is shown as 165,000 cfs while in other parts of the report the value stated is 168,000 cfs.					
6	VENTO	ED-WH	-GENERAL	GEN	
The report does not provide adequate information on the inability to incorporate the existing 2 pump stations into the permanent project. The issue is, can the existing pumping stations be modified to allow pumping against the higher head of the Corps project? Are the existing pumping stations located in the appropriate location to properly function as part of the permanent project? It may be possible to reduce the cost of the project by incorporating these pumps into the project.					
7	VENTO	ED-WH	-GENERAL	GEN	
The report needs to provide additional data to indicate that the proposal for only 2 outlets in sections 2 and 3 is the most cost effective proposal for interior flood control. The current proposal requires relatively large flows to be conveyed by the interceptor during gravity conditions. The report needs to indicate if the extra cost of additional outlets (and incorporation of existing outlets into the project) would be compensated by the reduction in the cost of the pipe required for the interceptor. (Frequently interceptors are only used during periods of blocked gravity drainage).					
	VENTO	ED-WH	-GENERAL	GEN	
The report proposes sizing the gravity outlets and interceptors to pass the SPF. This design parameter needs to be justified. Normally these components are sized to pass the 1% event and residual damages checked during the SPF.					

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File: C:\ARMS\CHAS4DM2.CMT

Printed: Tuesday May 7, 1991 at 3:06:15 p.m.

Project Info: CHASKA STAGE 4 DM NO. 2

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
1	WICKBOLDT	PE-PD-EC	-	ECO	
No comments					

File: C:\ARMS\CHAS4DM2.CMT

Printed: Tuesday May 21, 1991 at 7:19:04 a.m.

Project Info: Chask Stage 4 DM No. 2

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
1	SIMPSON	ED-TG	PA C-4, PA 17	GEO	
The existing embankment should be proof rolled before building on top of it.					
2	SIMPSON	ED-TG	PA C-5, PA 21	GEO	
Since both the steady seepage case and the intermediate river stage cases require long flood durations to saturate the relatively impervious embankment, they do not appear to be viable cases. Comment on this situation.					
3	SIMPSON	ED-TG	PA C-6, PA 22	GEO	
The soil strength after consolidation should be somewhere between the Q and R strength with a phi value. See Figure 3, page 14 of EM 1110-2-1902 and correct as necessary.					
4	SIMPSON	ED-TG	PA C-6, PA 22	GEO	
Discuss if stress/strain curves of the embankment and soft foundation are significantly different so that adjustments should be made to strength values. See DM 7.01, dated 1 September 1986, page 7.1-332. The assumed equal strain concept may not be correct for this case.					
5	SIMPSON	ED-TG	PA C-6, PA 22	GEO	
Strength values for normally consolidated soils should increase with depths. UTEXAS-2 input should reflect this. Verify that your results are correct or provide rationale that supports the data presented. It appears an average foundation soil strength of 400 psi is more likely.					
6	SIMPSON	ED-TG	PA C-7, PA 25	GEO	
Restudy the assumed cracking depth of approximately 15 feet and other assumptions. A crack depth of between 7.5 to 10 feet may be more correct. If berms are used to limit lateral strain the crack depth may even be less. See formula on page 43 of Contract Report S-76-6, titled "The Role of Fill Strength in the Stability of Embankments on Soft Clay." Preliminary computations here gave a factor of safety of 1.2 for a crack depth of 7.5 feet. Other input was as follows:					
<ul style="list-style-type: none"> <li>a. End of construction</li> <li>b. NCS soil strengths and location</li> <li>c. Full levee height at Sta. 14+00; 30 ft wide and 5 ft deep berm.</li> <li>d. Circle Tangent 675.0 ft</li> <li>e. Circle Center 83.0; 775.0 ft</li> <li>f. No search. It was found when allowing a computer search that the critical circle moved down the land ward slope toward a bearing capacity, situation not a slope stability problem. It was noted a foundation soil strength of 400 psi gives a factor of safety of 1.4.</li> </ul>					



File: C:\ARMS\CHAS4DM2.CMT

Printed: Tuesday May 21, 1991 at 7:19:12 a.m.

Project Info: Chask Stage 4 DM No. 2

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
7	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
NCS computations for this lower bound, deeper than usual crack analysis, indicates that the end of construction case probably has a stability Factor of Safety (FS)=1.0 or greater. Although less than the required FS=1.3 the gain in strength with consolidation could in a comparative short time period, make all stability cases acceptable. Furnish computations for time consolidation and discuss this approach.					
8	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
Explain how the existing levees were constructed almost to the proposed levees height on the same foundation without apparent stability problems.					
9	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
In several borings, soft clays were noted to be shallow (around elev. 680.0 and above) and bracketed by granular material that would provide rapid drainage for consolidation and the needed increase of strength. Explain why wick drains are necessary in these areas.					
10	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
If the proposed embankment fill strength is greater than 1200 psf, the initial stability would be higher and the need for wick drains might be eliminated. This condition/alternative of more compaction and higher embankment strength should be evaluated.					
11	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
Since slope failures would most likely occur during construction and could be remedied by the contractor, the economic consequences and flood risk of some sloughing could be limited. Therefore a factor of safety of greater than 1.0 but less than 1.3 might be tolerable for a limited time period. Comment on this aspect.					
12	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
The district should reanalyze the soft foundation situation using one or more of the following alternatives to wick drains: increased compaction and embankment strength, controlled sequence of placement, stability berms, reduced cracking depth (stability berms should limit lateral strain so there would be little or no cracking), a sandwich drain of granular material between the new embankment and the soft foundation and one or two stage construction as necessary.					
13	SIMPSON	ED-TG	PG C-8, PA 26	GEO	
Explain CSETT input and time rate of settlement computations so this can be reviewed.					

NCS computations for this lower bound, deeper than usual crack analysis, indicates that the end of construction case probably has a stability Factor of Safety (FS)=1.0 or greater. Although less than the required FS=1.3 the gain in strength with consolidation could in a comparative short time period, make all stability cases acceptable. Furnish computations for time consolidation and discuss this approach.

Explain how the existing levees were constructed almost to the proposed levees height on the same foundation without apparent stability problems.

In several borings, soft clays were noted to be shallow (around elev. 680.0 and above) and bracketed by granular material that would provide rapid drainage for consolidation and the needed increase of strength. Explain why wick drains are necessary in these areas.

If the proposed embankment fill strength is greater than 1200 psf, the initial stability would be higher and the need for wick drains might be eliminated. This condition/alternative of more compaction and higher embankment strength should be evaluated.

Since slope failures would most likely occur during construction and could be remedied by the contractor, the economic consequences and flood risk of some sloughing could be limited. Therefore a factor of safety of greater than 1.0 but less than 1.3 might be tolerable for a limited time period. Comment on this aspect.

The district should reanalyze the soft foundation situation using one or more of the following alternatives to wick drains: increased compaction and embankment strength, controlled sequence of placement, stability berms, reduced cracking depth (stability berms should limit lateral strain so there would be little or no cracking), a sandwich drain of granular material between the new embankment and the soft foundation and one or two stage construction as necessary.

Explain CSETT input and time rate of settlement computations so this can be reviewed.

File: C:\ARMS\CHAS4DM2.CMT

Printed: Tuesday May 21, 1991 at 7:19:22 a.m.

Project Info: Chask Stage 4 DM No. 2

Num	Name	Office	Page/Sheet	Discipline	Rm/Detail
14	SIMPSON	ED-TG	PG C-9, PA 32	GEO	

Relief wells should be eliminated if possible. The following, less costly, alternatives were not addressed in the DM No. 2 and should be investigated:

(a). Use of landside seepage berms with a width of berm plus the levee base width not greater than ten times the levee height, but in no case with a width less than 30 feet. (NCR has had success with this design in many similar situations along the Mississippi River)

(b). A pervious toe trench and a horizontal drainage blanket as shown in EIM 1110-2-1913, on page 5-4. This design should be verified using a flow net to see if exit gradients and seepage quantities are manageable.

(c). A partially penetrating slurry trench that would not cut off flow of groundwater toward the stream.

15	SIMPSON	ED-TG	PG C-9, PA 32	GEO	
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Discuss foundation selection, bearing capacity, etc. for all significant structures.

16	SIMPSON	ED-TG	PG C-7, PA 25	GEO	
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It was noted of the 14 borings in the soft areas where wick drains are proposed (between stations 7+50 and 30+50), that only 5 have questionable soil strength for stability. Justify wick drains for the entire reach.

17	SIMPSON	ED-TG	PG-C12, PA 46	GEO	
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Enclosed for guidance in design are the following:

- Pages 190 through 194 of "Seepage, Drainage and Flow Nets," by Cedergren for wick drain design. It was noted that wick drain design was incomplete as computations for spacing, time of consolidation, flow rate, etc. were not found. However, wick drains should be eliminated if possible as per the above comments.
- Sketch of sandwich drains to relieve construction pore pressures. This is a possible alternate to wick drains.
- Typical flow net for a section having a pervious toe trench. This would be an alternate to relief wells.

plane flow is very limited, and usually cannot exceed a few percent, or more than several feet in a horizontal distance of 100 ft. The comparison is made as follows:

Flow Across the Plane of a Fabric (Transverse Flow):

Assume a 12-in.  $\times$  12-in. area, for  $a_1 = 1.0$  sq. ft.

Assume an allowable hydraulic gradient  $i_1 = 5.0$ .

$$\text{Then, } q_1 = k_1 i_1 a_1 = k_1 (5.0) (1.0) = 5.0 k_1$$

Flow Along the Plane of a Fabric (In-Plane Flow):

Assume 1/8 in. thickness and a 12-in. wide strip, for  $a_2 = 0.01$  sq. ft.

Allow a hydraulic gradient of 0.05 (5 ft. of head loss/100 ft.) for  $i_2 = 0.05$

$$\text{Then, } q_2 = k_2 i_2 a_2 = k_2 (0.05)(0.01) = 0.0005 k_2$$

Ratio of Flow Rate Along Plane of Filter Fabric to Flow Rate Across:

Assuming that  $k_1 = k_2$ :

$$q_2/q_1 = 0.0005/5 = 0.0001$$

So the flow rate along the plane of the fabric is 1/10,000 th of that across (for equal permeabilities in both directions).

Even if the hydraulic gradient *across* the fabric were limited to 1.0, the flow rate along the plane would be only 1/2,000th of that across. Clearly, filter fabrics that can serve well as filters to protect permeable drainage layers may be virtually useless as conveyors of water along their plane. So, too much should not be expected of filter fabrics for *in-plane* flow. Before such a usage is contemplated, the discharge needs should be calculated and no material used that cannot remove at least 4 or 5 times the estimated rate (for a theoretical factor of safety of at least 4 or 5).

### Flow Capabilities of Composite Synthetic Drains

Composite Synthetic Drains (also called Prefabricated Drainage Composites) make use of high water-transmitting, high strength plastic cores enveloped within fabric filters. There are many varieties of composite drains used for a wide range of purposes. Some are for protecting walls and floors of basements from groundwater seepage. A type called *wick* drains is used as a replacement for the conventional sand drain for increasing the rate of consolidation of soft, compressible clay and peat foundations for embankments, as described in Sec. 7.2 under "Vertical Drains". Wick drains have a strong inner core with

high vertical discharge capability, wrapped within a fabric filter strong enough to resist forces produced when they are driven into the ground. They are driven vertically downward with special vibrating tools into soft formations that need to be rapidly consolidated so embankments can be placed over the formations after a reasonable consolidation period under partial load, without the danger of failing.

Another very common type of composite drain, sometimes called the *fin* drain, uses a strong plastic core with high vertical transmissibility that conducts seepage to a collector-discharge pipe at the bottom for removal to safe exits. The whole assembly is wrapped within a fabric filter. One of the first of this kind—if not the first—was developed by and patented by Healy and Long (1971). They used a core of corrugated or otherwise formed plastic material to provide vertical channels for downward conduction of water to the pipe at the bottom. A fabric filter enclosed the whole assembly. They emphasize that the cross-sectional area of the channels must be larger than the openings in the fabric to allow the few particles that wash through the fabric to wash into the pipe and out of the system.

The use of two kinds of plastic materials in the composite drains offers a way to obtain high flow rates with synthetic drains. The effectiveness of the composite drains lies in the fact that they are a *two-material system*, with one material serving as a filter and another as a water-conducting element. As with mineral aggregates, it is virtually impossible to achieve both good filtering and high water-removing capability with a single material (see Sec. 5.1). Effective water removal with the composite drains depends on a core structure that has high strength and contains rather large passageways for the water to travel freely to a pipe or other exit. Because this kind of drain is relatively thin in comparison with a trench backfilled with permeable aggregate, the discharge capabilities of some of the composites are in a relatively low range. Others that have high compressive strength and flow channels with effective diameters of 0.5 in. and greater, can have large flow capabilities.

Before designing a drainage system making use of composite drains, the engineer should make his best estimates of the quantities of water that need to be removed, using Darcy's law ( $q = kiA$ ) with realistic coefficients of permeability of the formations from which water flows, hydraulic gradient inducing the flow, and the area through which water is flowing to a pipe drainage system. Then materials for core, and size of pipe should be selected with manufacturer's ratings (or user's tests) of discharge capabilities of the materials to be used.

To illustrate the basic capabilities of vertical composite drains for removing water, I prepared Table 5.3 for several sizes of flow channels and several ranges of "effective" or "quasi" coefficients of permeability of core materials. Hydraulic gradients (in the drains) range from 0.02 to 1.0. For vertically downward flow the gradient can be 1.0 (100%), but for other flow conditions it may be as low as 1 or 2 percent. Though it is based on hypothetical conditions, I believe Table 5.3 illustrates the general order of magnitude of flow

**TABLE 5.3** Estimated Flow Rates for Composite Drains with Highly Permeable Cores

Effective flow channel dia., in.	Thick-ness, in.	Estimated turbulence factor, $C$	Estimated "quasi" $k'$ , ft/day	Hydraulic gradient, $i$	Estimated flow rates*	
					cu ft/day per foot	gpm per foot
0.25	0.3	0.20	16,000	1.0	360	2.0
		0.27	23,000	0.5	258	1.34
		0.50	33,000	0.1	74	0.39
		0.65	50,000	0.05	56	0.29
		0.90	80,000	0.02	36	0.19
0.5	0.6	0.16	60,000	1.0	2700	14.0
		0.21	78,000	0.5	1760	9.2
		0.42	156,000	0.1	700	3.6
		0.55	206,000	0.05	464	2.4
		0.86	320,000	0.02	290	1.5
0.8	1.0	0.12	100,000	1.0	7500	39.1
		0.16	134,000	0.5	5025	26.1
		0.36	300,000	0.1	2750	11.7
		0.50	416,000	0.05	1560	8.1
		0.85	610,000	0.02	915	4.8

\*Approximations, based on Quasi Darcy  $k$  values obtained for turbulent conditions (see Fig. 3.30) and  $q = k'iA$ , with the effective discharge area,  $A$ , equal to 90% of the cross-sectional area of a composite drain. Each composite drain type should be tested for its flow rate for specified hydraulic gradient and confining pressure.

possible in composite drains. The sketches in Figure 5.14 show basic arrangements for two kinds of prefabricated composite fabric drains. A "fin" drain with downward flow to a collector-discharge pipe is shown in Figure 5.14a, and so-called "wick" drains with upward flow are shown in Figure 5.14b. A schematic cross section for drains of these kinds is given in Figure 5.14c. The calculated flow rates, as given in Table 5.3 are for hydraulic gradients ranging from 1.0 to 0.02 and effective flow channel diameters of 0.25 in., 0.50 in., and 0.80 in.

In Table 5.3 it can be seen that for downward flow under a hydraulic gradient of 1.0 in a vertical drain with a thickness of 0.3 in. and an effective flow channel diameter of 0.25 in. the potential rate of flow is 2 gpm per foot. For a 100-ft length of drain, the flow capability would be 200 gpm, which is a substantial amount of water. If one of these drains was installed in a sandy soil with a coefficient of permeability of 50 ft/day, and a hydraulic gradient of 0.5 inducing flow to the drain, the inflow into a 20-ft deep drain would be about 5 gpm per 100 ft. from one side.

Referring again to Table 5.3, it is seen that the upward flow rate for a drain with a quasi coefficient of permeability of 80,000 ft/day and a hydraulic gradient,  $i = 0.02$ , would be 0.19 gpm per foot of width, or 0.063 gpm for a

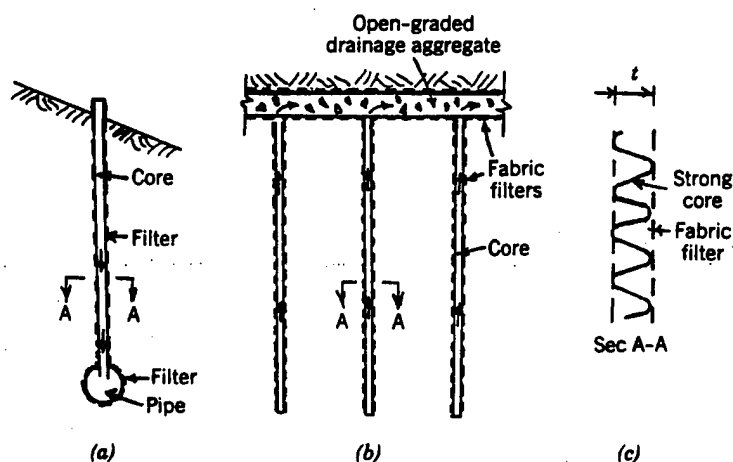


FIG. 5.14 Illustration of two kinds of composite synthetic drains, (a) Fin drain, (b) Wick drains, (c) schematic section A-A through typical prefabricated drain.

4-in wide wick drain. This would be 91 gallons per day or 12 cu ft/day for a single drain. Each cubic foot of water removed from a wick drain represents that amount of consolidation of the soil within its influence. With drains at a 4-ft spacing in both directions, 12 cu ft/day would represent  $(12 \text{ cu ft/day}) / (16 \text{ sq. ft.}) = 0.75 \text{ ft/day}$  of consolidation, which is a very significant amount.

The flow rates in Table 5.3 are presented as rough indicators of potential rates for the conditions assumed. All prefabricated drains to be used in projects should have their capabilities tested before they are used to make sure they can perform as required.

Koerner (1986) made flow tests on a variety of "prefabricated drainage composites" using laboratory equipment that could handle up to 100 gpm per foot with applied normal pressures up to 30 psi for long periods of time. Fabrics with weak core structure had big reductions in flow under higher pressures, but three of the composites tested had large flow rates with little reduction under increasing pressure. One—measuring 2.8 cm in thickness with a core made up of columns of polyethylene 7 mm in diameter at 2 cm centers—had a flow rate of about 80 gpm under all pressures. Another—2.5 cm thick, with a "waffle" core of polystyrene—had flow rates of 12 to 11 gpm per foot under pressures from zero to 30 psi. The third—0.5 cm thick with a 0.75 cm grid of polypropylene for its core—had a flow rate of 2 gpm per foot, with no measurable reduction with increased pressure. All of the flow rates given here are for a hydraulic gradient of 1.0. Koerner concludes that more information is needed from manufacturers on flow rates of their products. He says specifications for composite drains should "list a minimum flow rate at a stipulated hydraulic gradient and applied pressure". Also, the protective filter "cannot intrude (much less fail) between the flow channels of the core material." His work is very timely as it gives answers to the key question about

prefabricated drains, "What is their capability for discharging water under field conditions?" As discussed at length in this chapter and elsewhere in this book, the discharge capabilities of all kinds of drains for engineering works is of prime importance.

Chen and Chen (1986) made tests on permeability characteristics of five prefabricated vertical drains and found that drain materials with thicker and harder cores had higher permeabilities than thinner and weaker core materials. Also, the large flow channels gave higher permeabilities than smaller ones. They found that Calhoun's criterion,  $0_{95}/d_{85} \leq 2$  or 3, was better than another criterion that had been suggested. With soil confinement they obtained permeability values in the range of 11-21 cm/sec at 0.2 Kg/cm<sup>2</sup> pressure to 8-15 at 3.0 Kg/cm<sup>2</sup> confining pressure. Without soil confinement they obtained permeabilities in the range of 18-30 cm/sec at 0.2 Kg/cm<sup>2</sup> pressure to 10-24 cm/sec at 3.0 Kg/cm<sup>2</sup> confining pressure.

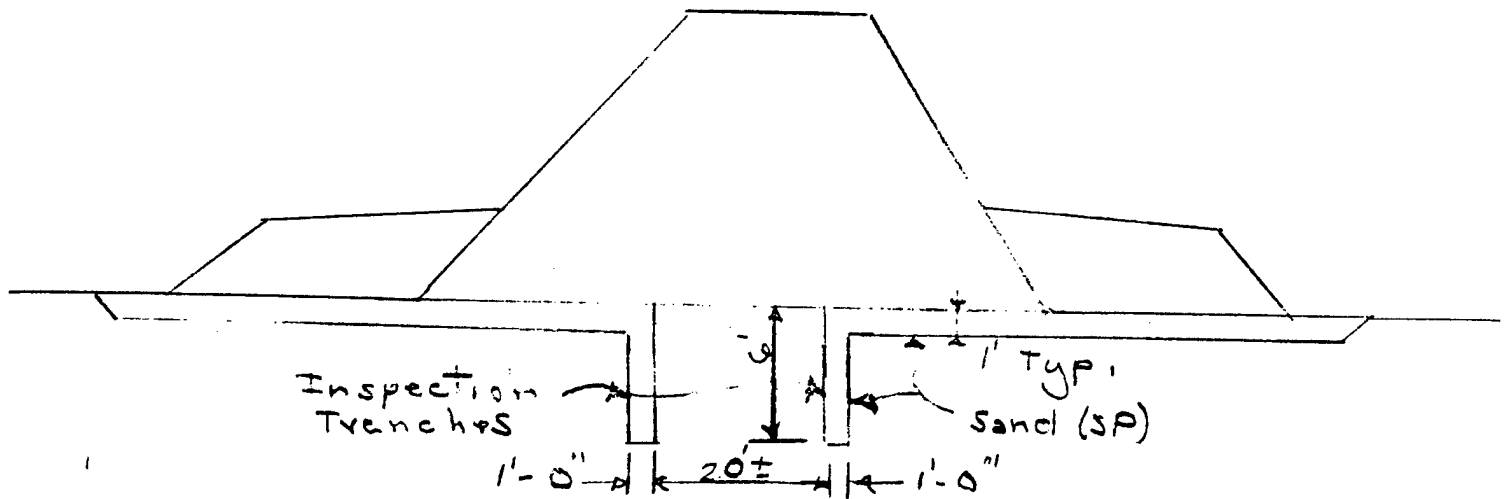
Suits (1986) describes procedures used by the New York State Department of Transportation (NYSDOT) to determine the acceptability of prefabricated wick drains. He concludes that rigid core drains lose very little flow capacity under confining pressures, but soft core prefabricated drains lost 50% to 90% of their flow capacity under the same loads applied to those with rigid cores. Flows of 30 cc/sec to 210 cc/sec were obtained through rigid core drains. Like California Dept. of Transportation, New York State DOT requires that wick drains be installed with a protective mandrel. Spacings have been between 4 and 7 feet for three projects that all gave excellent performance.

Prysock and Walsh (1988) describe methods used by the California Department of Transportation (CALTRANS) to test prefabricated vertical drains for flow capacity characteristics to determine suitability for use. Sections of drain are immersed in water in a testing device that forces water to flow through the fabric and out through the core. A limiting pressure is set up for acceptance of any specimen proposed for use in a state project.

## 5.8 SPECIFICATIONS FOR AGGREGATE FILTERS AND DRAINS

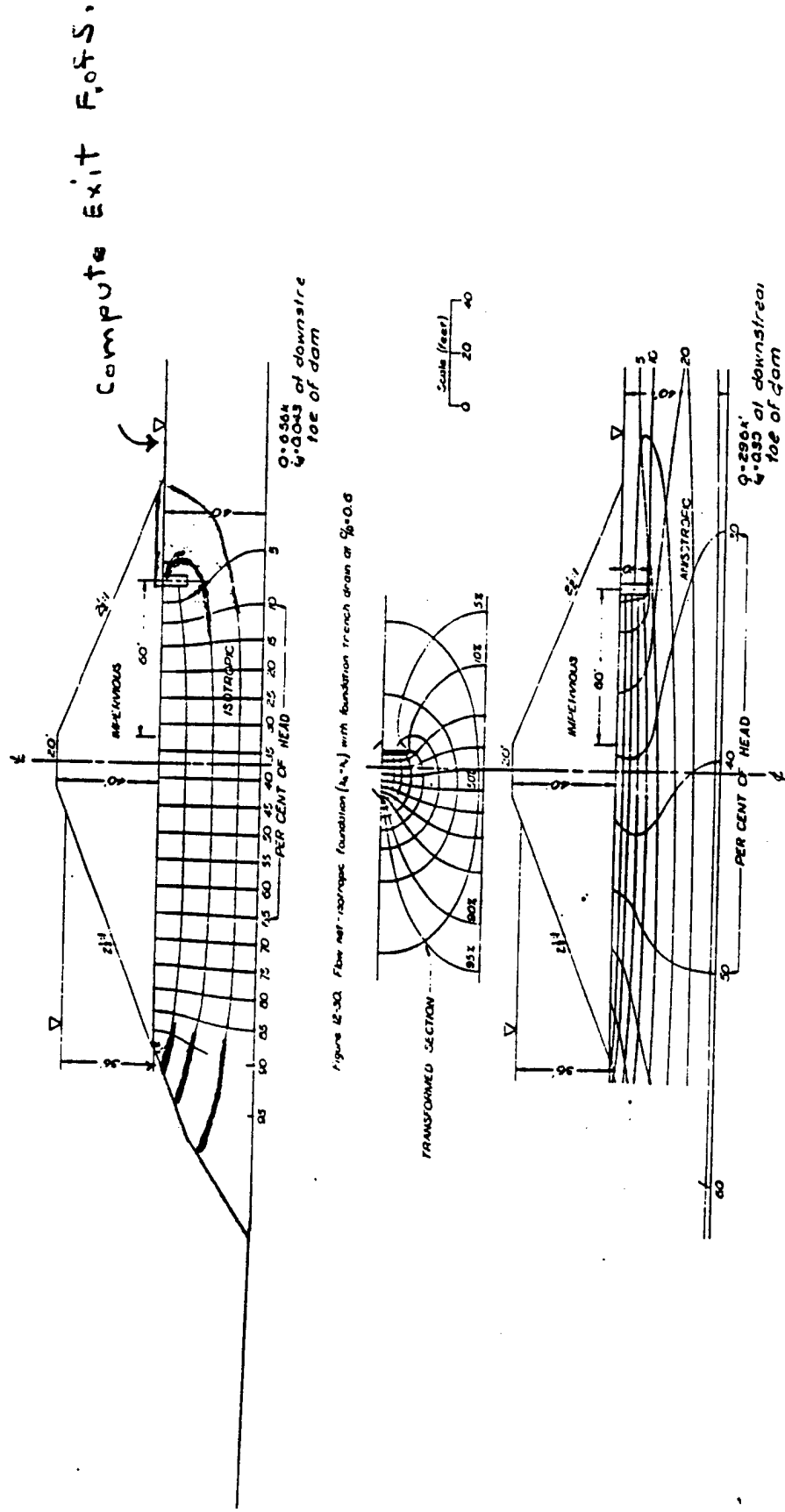
Although naturally occurring gravels and sands can sometimes be used for filters and drains with little or no processing, drainage aggregates usually need to be treated. Efforts to save money by using untreated local materials almost always produce marginal or unsatisfactory filters and drains. Most natural sand and gravel deposits are highly variable in grading from point to point in a borrow area or are covered or interbedded with silt and clay that is difficult to remove. Rarely, natural deposits of clean washed beach sands are potential sources of permeable materials for highway drainage. Other relatively uniform natural deposits which are located near projects can be looked on as possible sources. When feasible, local deposits should be explored with drill holes, test pits, and trenches and tested for grain-size distribution. Usually, however, nat-

# Foundation Sandwich Drains





# Flow Net Example (not this project)



Note: An isotropic analysis is probably not necessary but should be considered if horizontal and vertical permeabilities differ significantly.

CENCD-PE-ED-TM (CECW-EP-E/21 Oct 91) (1110-2-1150a) 3d End  
Mr. Ordonez/mgb/(312) 353-9057  
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

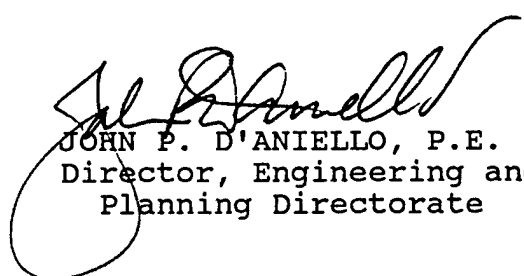
Commander, North Central Division, U.S. Army Corps of Engineers,  
141 North Canal Street, Chicago, IL 60606-7205 23 JAN 1992

FOR HQUSACE (CECW-EP-E/Mr. Smith), WASH DC 20314-1000

1. Forwarded are NCS responses to your review comments on the DM. These responses have been reviewed by NCD staff and are satisfactory, except the response to comment 2a.
2. In order to provide a satisfactory response to comment 2a, NCD requested that the district conduct additional work to confirm that no hazardous or regulated materials are within the project area. The district agreed to do the work prior to the preparation of the plans and specifications. The items of work are listed in enclosure 4.
3. The HQ, NCD, POC is Mr. Jose Ordonez, (312) 353-9057.

FOR THE COMMANDER:

4 Encls  
1-3. nc  
Added 1 encl  
4. as

  
JOHN P. D'ANIELLO, P.E.  
Director, Engineering and  
Planning Directorate

CF:  
CENCS-ED-M (Mr. Hyerman) w/encl 4  
CENCS-PP-PM (Mr. Raasch) w/encl 4

CECW-EP-E (CECW-EP-E/21 Oct 91) (1110-2-1150a) 4th End SMITH/tf/  
(202) 272-8951

SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum (DM) No. 2, Stage 4, Minnesota River

21 FEB 1992

HQ, U.S. Army Corps of Engineers, Washington, DC 20314-1000

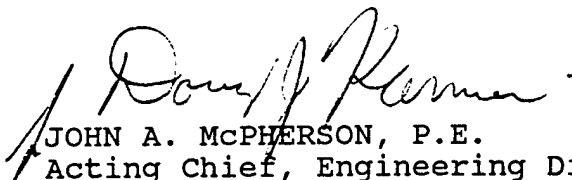
FOR Commander, North Central Division, ATTN: CENCD-PE-ED

The NCS responses to HQ review comments on the subject DM are  
satisfactory, except for the following:

We concur with the district that the level of detail for real  
estate requirements for this stage work is appropriate. The fact  
remains, however, that a more complete real estate section for the  
subject memorandum is appropriate. Future reports should include a  
comprehensive and concise real estate section addressing real  
estate requirements, costs, schedules, etc., in one place in the  
memorandum or report.

FOR THE DIRECTOR OF CIVIL WORKS:

4 Encls  
wd all encls

  
JOHN A. MCPHERSON, P.E.  
Acting Chief, Engineering Division  
Directorate of Civil Works

CENCD-PE-ED-TM (CECW-EP-E/21 Oct 91) (1110-2-1150a) 5th End  
Mr. Ordonez/mgb/(312) 353-9057  
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum (DM) N. 2, Stage 4, Minnesota River

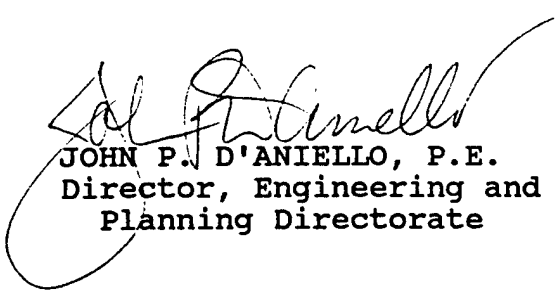
Commander, North Central Division, U.S. Army Corps of Engineers,  
141 North Canal Street, Chicago, IL 60606-7205 18 MAR 1992

FOR Commander, St. Paul District, ATTN: CENCS-ED-M

1. Forwarded for your information and guidance.
2. The HQ, NCD, POC is Mr. Jose Ordonez, CENCD-PE-ED-TM,  
(312) 353-9057.

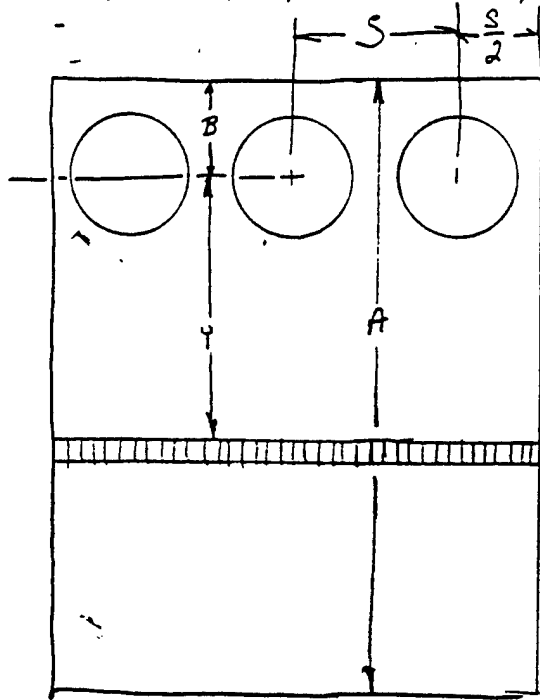
FOR THE COMMANDER:

Encl  
nc

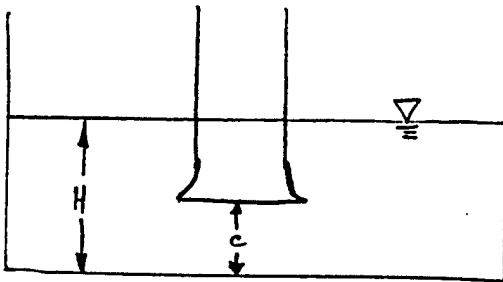
  
JOHN P. D'ANIELLO, P.E.  
Director, Engineering and  
Planning Directorate

CF:  
CENCS-PP-PM (Mr. D. Raasch)

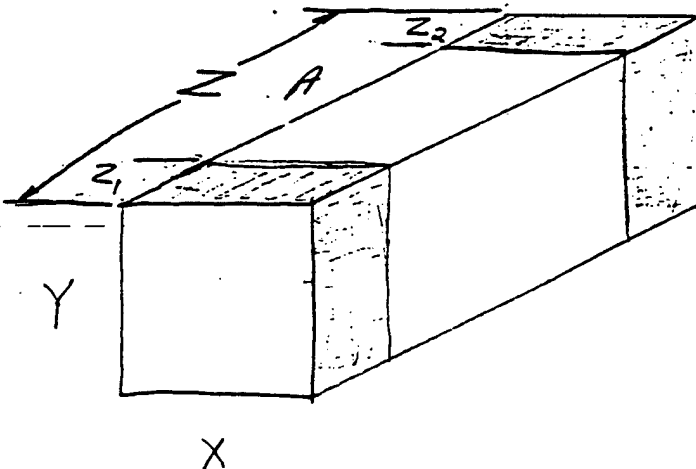
# PRELIMINARY SUMP DIMENSIONS from H.I.S. p 126



	6-8 kppm	12-14 kppm.
✓ A	140	200
✓ B	23 + (50)	33 + (50)
✓ C	18	22.5
✓ H	60	80
✓ S	56	73.
✓ Y	95	130



298



$Z_1$  - interceptor chamber  
 $Z_2$  - discharge riser chamber

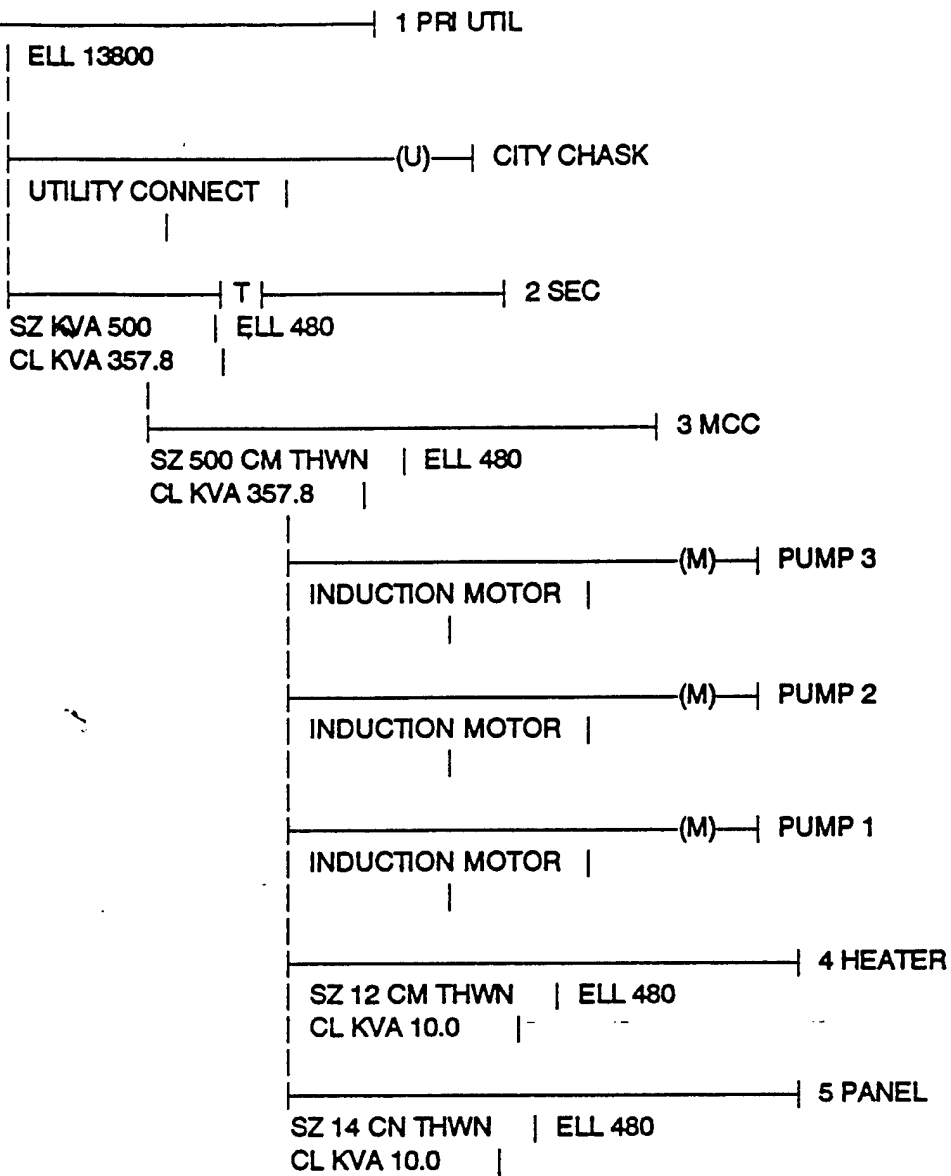
$$Z_1 = 66'' + 12'' = 78''$$

$$Z_2 = 50''$$

$$\Delta Q = 13' = 156''$$

ENCL #1

1 ONELINE



ENCL\*2

DATE: 19 NOV 91 TIME: 4 49 PM  
MCC SCHEDULE: 3 MCC

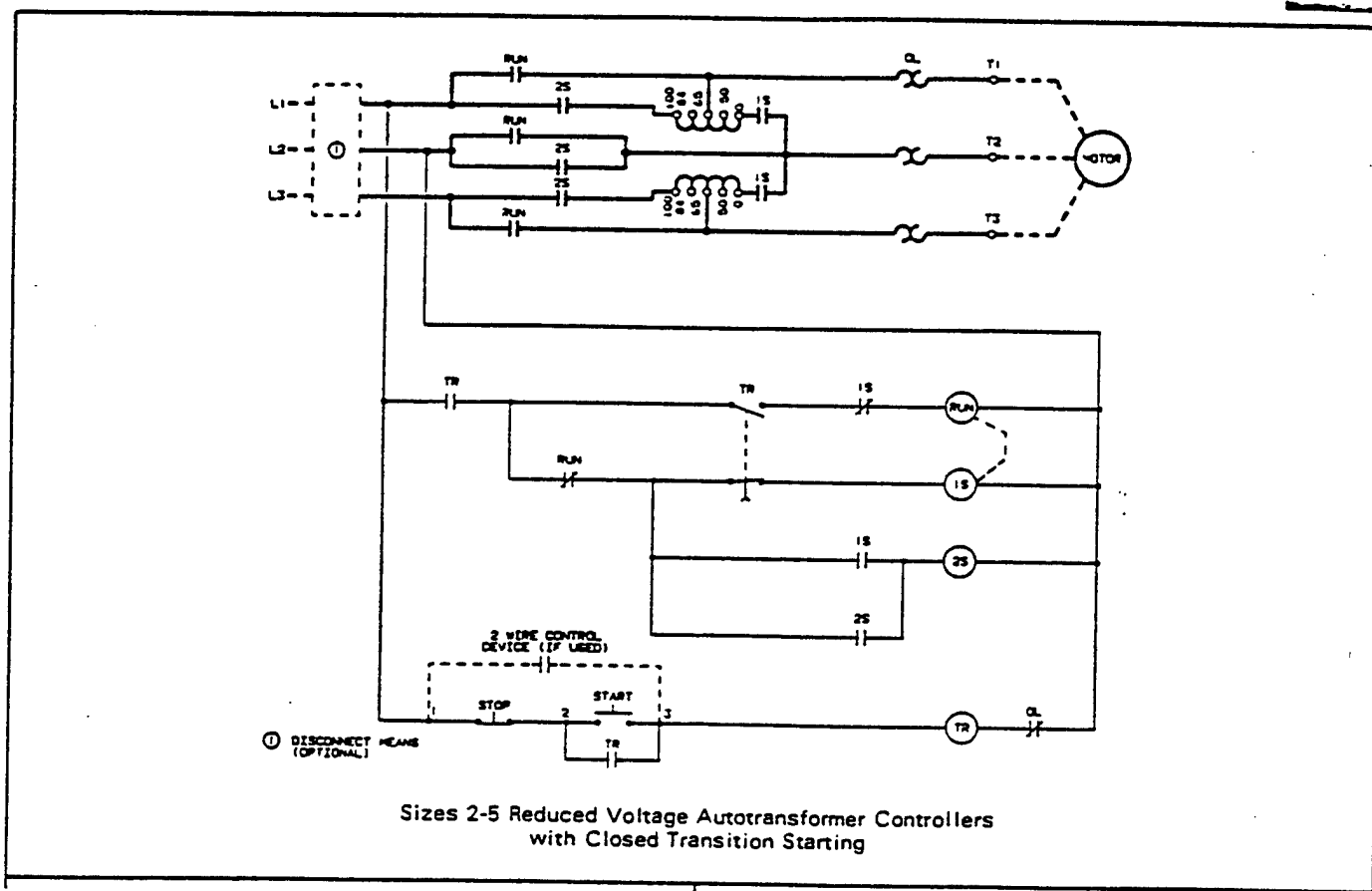
PAGE: 2  
3 PHASE 3 WIRE

O.C. Device type: BREAKERS Mounting: FLOOR Voltage LL: 480  
Device Family: ] Enclosure: NEMA 1 Voltage LG:  
Bus Amps: Comments: Fault Duty: 17814

Ck No	Description/ Location	Hp Size	Fla	Dem Cd	*OC Device* Type	Amps	P	Starter Sz	#X Type	Ac Raceway/Fdr Sp	Sz Gp
1	STORM WATER PUMP 1	100	124	10	MCP	250	3	5	FVNR	6X	2"C 3"2/0
2	STORM WATER PUMP 2	100	124	9	MCP	250	3	5	FVNR	6X	2"C 3"2/0
3	STORM WATER PUMP 3	100	124	9	MCP	250	3	5	FVNR	6X	2"C 3"2/0
4	SUMP PUMP	2	3.4	9	MCP	7	3	1	FVNR	2X	1/2"C 3#14
5	CRANE	2	3.4	9	MCP	7	3	1	FVNR	2X	1/2"C 3#14
6	SANITARY PUMP 1	10	14	9	MCP	30	3	1	FVNR	2X	1/2"C 3#12
7	SANITARY PUMP 2	10	14	9	MCP	30	3	1	FVNR	2X	1/2"C 3#12
8	\$\$HEATER	4	12								
9	\$\$PANEL	5	12								
10	SPACE										

TOTAL LOADS: CONNECTED KVA: 357.9 DEMAND KVA: 357.9 DESIGN KVA: 383.6  
CONNECTED FLA: 430.4 DEMAND FLA: 430.4 DESIGN FLA: 461.4

## REDUCED VOLTAGE CONTROLLERS AUTOTRANSFORMER TYPE



CHASKA STAGE 4

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

DATE: 18 NOV 91

TIME: 2 18 PM

-----  
ALL INFORMATION PRESENTED IS FOR REVIEW, APPROVAL  
INTERPRETATION AND APPLICATION BY A REGISTERED  
ENGINEER ONLY  
-----

-----  
DAPPER (LOAD FLOW AND VOLTAGE DROP MINI/MICRO VERSION 3.5 LEVEL 2.1)  
COURTIGHT SKM SYSTEMS ANALYSIS, INC. 1983  
-----

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

F E E D E R   D A T A

FEEDER FROM NO NAME	FEEDER TO NO NAME	QTY /PH	VOLTS L-L	LENGTH	FEEDER SIZE	DESCRIPTION TYPE DUCT INSUL
2 SEC	3 MCC	2	480.	75. FT	500	C M THWN
IMPEDANCE:	.0294 + J	.0466	OHMS/M FEET			
3 MCC	4 HEATER	1	480.	30. FT	12	C M THWN
IMPEDANCE:	1.8700 + J	.0910	OHMS/M FEET			
3 MCC	5 PANEL	1	480.	30. FT	14	C N THWN
IMPEDANCE:	2.9700 + J	.0961	OHMS/M FEET			

SOURCE BUS THEVENIN EQUIVALENT IMPEDANCE: .007049418 + J .211482600 OHMS  
Calculated From Largest 3-PHASE Fault Contribution

ENCL \*3



DATE:18 NOV 91 TIME: 2 18 PM  
CHASKA STAGE 4

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

TRANSFORMER DATA

PRIMARY RECORD NO NAME	VOLTS L-L	PRI FLA	* SECONDARY RECORD NO NAME	VOLTS L-L	SEC FLA	NOMINAL KVA
1 PRI UTIL^ IMPEDANCE: 1.0000 + J 4.8989 PERCENT	13800.	21.	2 SEC	480.	601.	500.0

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

BRANCH LOAD DATA

FROM BUS	TO BUS	BR. TYPE	CONSTANT KVA KVA	%PF	CONSTANT Z KVA	%PF	CONSTANT I KVA	FLOW %PF DIR.
2 SEC								
3 MCC		FEEDER	357	-80.6				
3 MCC								
4 HEATER		FEEDER	10	-90.0				
5 PANEL		FEEDER	10	-90.0				
1 PRI UTIL								
2 SEC		TRANS.	357	-80.6				

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

\*\*\* SOLUTION COMMENTS \*\*\*

SOLUTION PARAMETERS

PER UNIT DRIVING VOLTAGE : 1.0000  
BRANCH VOLTAGE CRITERIA : 4.00 %  
BUS VOLTAGE CRITERIA : 5.00 %  
EXACT(ITERATIVE) SOLUTION : YES  
TRANSFORMERS MODELED : YES

<<PERCENT VOLTAGE DROPS ARE BASED ON NOMINAL DESIGN VOLTAGES>>

TOF SIZE: 19

LARGEST LOAD: 338.21 KVA  
CONVERGENCE CRITERIA: .017 KVA  
LARGEST BUS MISMATCH 3 MCC 19.445 KVA  
LARGEST BUS MISMATCH 3 MCC .813 KVA  
LARGEST BUS MISMATCH 3 MCC .034 KVA  
LARGEST BUS MISMATCH 3 MCC .001 KVA

DATE: 18 NOV 91 TIME: 2 18 PM  
CHASKA STAGE 4

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

BALANCED VOLTAGE DROP AND LOAD FLOW ANALYSIS (BRANCH LOAD REPORT)

\*\*\*\*\*  
VOLTAGE EFFECT ON LOADS MODELED TRANSFORMER VOLTAGE DROP MODELED  
VOLTAGE DROP CRITERIA: BRANCH - 4.00 % BUS - 5.00  
PER UNIT DRIVING VOLTAGE - 1.0000

LOAD BUS: 1 PRI UTIL DESIGN VOLTAGE: 13800 LOAD VOLTAGE: 13796 %VD: .0  
----- VOLTAGE ANGLE: .0 DEGREES  
LOAD FROM: \*\*\*\* SOURCE FEEDER AMPS: 15 VOLTAGE DROP: 0. %VD: .00  
PROJECTED POWER FLOW: 292. KW 226. KVAR 369. KVA PF: .79 LAGGING  
LOSSES THRU FEEDER: 0. KW 0. KVAR 0. KVA

LOAD BUS: 2 SEC DESIGN VOLTAGE: 480 LOAD VOLTAGE: 467 %VD: 2.8  
----- VOLTAGE ANGLE: -1.4 DEGREES  
LOAD FROM: 1 PRI UTIL TRANSF AMPS: 444 VOLTAGE DROP: 13. %VD: 2.77  
PROJECTED POWER FLOW: 289. KW 213. KVAR 359. KVA PF: .81 LAGGING  
LOSSES THRU TRANSF: 2.7 KW 13.4 KVAR 13.6 KVA

LOAD BUS: 3 MCC DESIGN VOLTAGE: 480 LOAD VOLTAGE: 465 %VD: 3.1  
----- VOLTAGE ANGLE: -1.5 DEGREES  
NET BRANCH DIVERSITY LOAD: 271. KW 203. KVAR  
LOAD FROM: 2 SEC FEEDER AMPS: 444 VOLTAGE DROP: 1. %VD: .31  
PROJECTED POWER FLOW: 289. KW 212. KVAR 358. KVA PF: .81 LAGGING  
LOSSES THRU FEEDER: 1. KW 1. KVAR 1. KVA

LOAD BUS: 4 HEATER DESIGN VOLTAGE: 480 LOAD VOLTAGE: 464 %VD: 3.3  
----- VOLTAGE ANGLE: -1.5 DEGREES  
NET BRANCH DIVERSITY LOAD: 9. KW 4. KVAR  
LOAD FROM: 3 MCC FEEDER AMPS: 12 VOLTAGE DROP: 1. %VD: .23  
PROJECTED POWER FLOW: 9. KW 4. KVAR 10. KVA PF: .90 LAGGING  
LOSSES THRU FEEDER: 0. KW 0. KVAR 0. KVA

LOAD BUS: 5 PANEL DESIGN VOLTAGE: 480 LOAD VOLTAGE: 463 %VD: 3.5  
----- VOLTAGE ANGLE: -1.4 DEGREES  
NET BRANCH DIVERSITY LOAD: 9. KW 4. KVAR  
LOAD FROM: 3 MCC FEEDER AMPS: 12 VOLTAGE DROP: 2. %VD: .37  
PROJECTED POWER FLOW: 9. KW 4. KVAR 10. KVA PF: .90 LAGGING  
LOSSES THRU FEEDER: 0. KW 0. KVAR 0. KVA

US ARMY CORPS OF ENGINEERS - ST. PAUL, MINNESOTA

BALANCED VOLTAGE DROP AND LOAD FLOW ANALYSIS (BRANCH LOAD REPORT)

\*\*\*\*\*  
VOLTAGE EFFECT ON LOADS MODELED TRANSFORMER VOLTAGE DROP MODELED  
VOLTAGE DROP CRITERIA: BRANCH - 4.00 % BUS - 5.00  
PER UNIT DRIVING VOLTAGE - 1.0000

5 BUSES

\*\*\* TOTAL SYSTEM LOSSES \*\*\*  
3. KW 14. KVAR

Chaska, MN Flood Control  
Scope of Additional Work to Determine  
Presence/Absence of Hazardous or Regulated Materials  
Within Project Area

St. Paul District determined that no known commercial or industrial establishments were located in the considered project area. St. Paul District will do the following to confirm that no hazardous, toxic, radiological nor regulated materials are within the considered project area:

a. The project will be coordinated with all applicable agencies, including the U.S. EPA, Minnesota Pollution Control Agency, the county and municipal agencies, to determine if they know or suspect any contaminated areas.

b. The site will be inspected when weather permits by personnel experienced in identifying potential contaminated areas. (This inspection will be similar to a DERP FUDS preliminary assessment). Suspect areas such as land fills, burn areas, abandoned industrial sites, utility lines or crossings, underground tanks or piping, areas with distressed vegetation, /etc. will be identified.

c. The above investigations will be documented to determine the need for any further investigations. The local sponsor, current owner and all applicable regulatory agencies will be informed of suspect areas requiring additional investigation and a scope of additional investigations will be developed as required.

d. The findings of the planned investigation, including the scope and estimate of additional studies required, will be documented in an addendum to the Design Memorandum and submitted to this office for review.

e. The above effort will be completed prior to completion of plans and specifications.

12 AUG 1991

CENCD-PE-ED-TM (CENCS-ED-M/24 Apr 91) (1110) <sup>3<sup>rd</sup></sup> ~~2nd~~ End  
Mr. Ordonez/amw/(312) 353-9057  
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

Commander, North Central Division, U.S. Army Corps of Engineers,  
111 N. Canal Street, Chicago, IL 60606-7205


FOR Commander, St. Paul District, ATTN: CENCS-ED-M

1. Your responses to CENCD review comments are satisfactory.  
The subject Design Memorandum is approved.

2. The HQ, NCD, POC is Mr. Jose Ordonez, (312) 353-9057.

FOR THE COMMANDER:

2 Encls  
nc

  
JOHN E. D'ANIELLO, P.E.  
Director, Engineering and  
Planning Directorate

CF:  
CECW-EP (w/ 10 copies encl 1)

CENCD-PE-ED-TM (CENCS-ED-M/24 Apr 91) (1110) <sup>3rd</sup> ~~2nd~~ End  
Mr. Ordonez/amw/(312) 353-9057  
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

Commander, North Central Division, U.S. Army Corps of Engineers,  
111 N. Canal Street, Chicago, IL 60606-7205

FOR Commander, St. Paul District, ATTN: CENCS-ED-M

1. Your responses to CENCD review comments are satisfactory.  
The subject Design Memorandum is approved.

2. The HQ, NCD, POC is Mr. Jose Ordonez, (312) 353-9057.

FOR THE COMMANDER:

2 Encls  
nc

JOHN P. D'ANIELLO, P.E.  
Director, Engineering and  
Planning Directorate

CF:  
CECW-EP (w/ 10 copies encl 1)

CENCD-PE-ED-TM (CENCS-ED-M/24 Apr 91) (1110) 1st End  
Mr. Ordonez/amw/(312)-353-9057  
SUBJECT: Flood Control, Minnesota River at Chaska, Minnesota,  
Design Memorandum No. 2, Stage 4, Minnesota River

Commander, North Central Division, U.S. Army Corps of Engineers,  
111 N. Canal Street, Chicago, IL 60606-7206

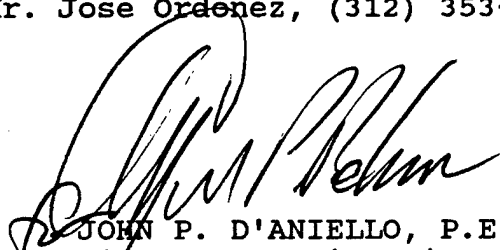
11 JUN 1991

FOR Commander, St. Paul District, ATTN: CENCS-ED-M

1. Approval of the subject report is held in abeyance until the  
enclosed CENCD comments are resolved.

2. The HQ, NCD, POC is Mr. Jose Ordonez, (312) 353-9057.

FOR THE COMMANDER:



JOHN P. D'ANIELLO, P.E.  
Director, Engineering and  
Planning Directorate

2 Encl  
wd encl

Added 1 encl

2. CENCD

Rec'd 19 Jun 91

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

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##### Letter

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C	GEOTECHNICAL DESIGN
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E	ARCHITECTURAL MECHANICAL ELECTRICAL
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G	COST ESTIMATE



MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

MAIN REPORT

SCOPE AND LOCATION

1. The flood control project at Chaska, Minnesota is divided into four stages of construction. This Design Memorandum (DM) presents the design and discussion of planning for Stage 4 which in general consists of a levee that protects Chaska from flooding of the Minnesota River. Work to be done includes approximately 4,200 feet of existing levee upgrading, 2,800 feet of new levee, one 18,000 gpm pumping station, 2 outlets with gatewells, interceptor pipe with manholes and inlets, relief wells and sanitary sewer with lift station.

PROJECT AUTHORIZATION

2. This project was authorized for construction under Public Law 94-587.

PROJECT DESCRIPTION - GENERAL

3. The Chaska Flood Control project consists of the following four stages:

- a. Stage 1, Road raise along Chaska Creek.
- b. Stage 2, Chaska Creek Diversion Channel.
- c. Stage 3, East Creek Diversion Channel.
- d. Stage 4, Minnesota River Levee.

Also included are recreational improvements, an environmental mitigation plan, and aesthetic consideration.

DEPARTURES FROM APPROVED GENERAL DESIGN MEMORANDUM

4. The design presented here essentially conforms to that shown in the General Design Memorandum, revised August 1984, except that the pumping station will be located at the end of Oak Street instead of Pine Street.

HYDROLOGY

5. Hydrologic information for this project is given in the Limited Reevaluation Report, August 1982. An elevation-frequency curve is presented there. No additional hydrologic analysis was required for this stage. The

levee is designed for the 1 percent chance flood and it will contain the water surface profile for the Standard Project Flood of 168,000 cfs for the Minnesota River at Chaska.

## GEOLOGY

6. A discussion of the geology for the project area is given in appendix C of this report.

## DESCRIPTION OF PROPOSED STRUCTURES

### LEVEE (Sheets 2 thru 13)

7. The levee construction will consist of about 4,200 feet of existing levee upgrading and about 2,800 feet of new levee. The levee upgrading portion will consist of increasing the existing levee height by about 3 feet. The new levee portion will be about 25 feet high. The levee design is discussed in appendixes B and C.

### PUMPING STATION (Sheets 25 thru 30)

8. A pumping station having a capacity of 18,000 gallons per minute will be located at the south end of Oak Street. It's superstructure will house the motor control centers for the storm water pumps and adjacent sanitary lift station, will act as the hub for all city flood control operations and maintenance, and will provide for storage of flood control equipment, materials, and supplies. The pump station design is discussed in appendixes A, D, and E.

### PONDING AREA (Sheet 1)

9. A storm water ponding area at Outlet A will be provided. This ponding area will be in the existing Chaska Creek just upstream from Outlet A. Outlet A was constructed during Stage 2 construction. About 1.7 acre feet of storage between elevations 713.5 and 718.5 will be provided. This will require about 1.55 acres of ponding easements. The sides of the ponding area will be graded, topsoiled and seeded so that the area can be maintained. Ponding markers will be added as required.

### OUTLETS (Sheets 21 thru 24)

10. Two outlets will be constructed to convey interior storm water through the levee to the Minnesota River. Twin 48" RCP's extending from the gatewells are recommended instead of a single pipe to:

- a. Eliminate the need for a large concrete energy dissipater.
- b. Eliminate freezing in the pipes by keeping their crowns below the normal low water line.

c. Eliminate sedimentation in the pipes by keeping their inverts above the bottom of the river.

The outlet design is discussed in appendix A.

#### RELIEF WELLS (Sheet 20)

11. Relief wells will be constructed just landward of the levee between about Stations 36+50 and 61+00. Relief wells are required to limit uplift pressures at the toe of the levee to acceptable values. The relief well design is discussed in appendix C.

#### LANDSCAPING

12. The levee and surrounding project area will be restored and landscaped. The location and proximity of the surrounding residential or other land uses will dictate the need for vegetative screening and provisions for enhancing or directing views. Design consideration will include the ease of maintenance and the incorporation of plant material that will offer seasonal color, bloom, fruit, hardiness, and wildlife shelter and food values. Additional considerations will be providing shade for trail users and maintaining plant selections that are consistent with Stage 2. The levee will have turf grasses established, with blue grass mixtures on the landward side for aesthetics purposes and prairie-type mixtures on the river side for wildlife purposes. In areas where it is deemed desirable to provide shrubs or shade on the levee, overburden will have to be provided to allow planting.

#### RECREATION

13. A multi-use trail will be provided on the top of the levee and around Courthouse Lake. It will consist of an 8-foot wide bituminous treadway with 1-foot wide aggregate shoulders. The trail will extend from and be continuous with the trail constructed in Stage 2. In the vicinity of Courthouse Lake, at approximately Station 29+00, a bituminous surfaced trail will be constructed linking the levee-top trail with a trail to be constructed around Courthouse Lake. From approximately Station 29+00 to Station 0+00, the levee-top trail's treadway will be stabilized aggregate during Stage 4 construction, with a bituminous trail added during Stage 3 construction. Lighting, safety rails, benches, trash receptacles will be provided as appropriate. Three informational kiosks will be provided; one near Courthouse Lake; one at the river access point near Cedar Street; and, one near the Chaska ballfield. The treadway will be fully accessible by mobility impaired visitors with the appropriate slopes and landings provided at major access points.

#### RELOCATIONS

#### UTILITIES, ROADS

14. As provided in the Local Cooperation Agreement (LCA), the Local Sponsor shall "accomplish or arrange for accomplishment at no cost to the Government of all alterations and relocations of buildings; highways; railroads; bridges (other than railroad bridges and approaches thereto); storm drains; utilities

(other than those portions which pass under or through the project structures); cemeteries; and other facilities, structures, and improvements determined by the Government to be necessary for construction of the project."

15. A table indicating the required utility modifications is given in appendix F. Three road relocations are required. These are in the area of Stations 7+00, 33+00, and 62+00.

#### SANITARY SEWER AND LIFT STATION

16. The existing sanitary sewer between Stations 34+00 and 71+00 will be relocated so that it is outside the levee and berm prism. It will be located just on the north side of the interceptor pipe. A sanitary lift station will be constructed in the area of the new storm water pump station at the end of Oak Street. This construction is classified as a relocation and as such is the Local Sponsor's responsibility to accomplish and pay for the design and construction. However, they will be given the option of:

- a. Designing and constructing the relocation.
- b. Designing the relocation and having it constructed with the Stage 4 flood control construction contract.
- c. Having it designed with the Stage 4 plans and specifications and having it constructed with the Stage 4 flood control construction contract.

#### ENVIRONMENTAL ANALYSIS

##### ENVIRONMENTAL SETTING

17. Land use along this reach of the project is a mix of residential development, commercial development and undeveloped lands. The levee reach along Chaska Creek is adjacent to the Minnesota National Wildlife Refuge. On the riverward side of the existing levee and along the alignment for the levee extension, vegetation types are a mix of riparian woods, floodplain wetland, and old field. Riparian woods vegetation includes silver maple, American elm, box elder, cottonwood, and willow with an understory of nettle and grasses. The floodplain wetland can be characterized as a woodland pond within the riparian areas and is located just east of Courthouse Lake. Dominant vegetation of the old field vegetation type includes staghorn sumac, willow, goldenrod, and grasses. Vegetation along the landward side of the existing levee is characteristic of an urban setting with backyards, commercial development, and an occasional park area.

##### ENVIRONMENTAL IMPACTS

18. Construction of the proposed features will result in the loss of approximately 10 acres of riparian woods and three acres of old field. Habitat losses to wildlife with project construction are being partially mitigated with the planting of upland vegetation on project lands in conjunction with the construction of Stage 2 along Chaska Creek. Shrubs and shrubby tree species such as dogwood, hazel, and russian olive with oak,

wildplum, chokecherry, maple, and ash are being planted. These areas will be managed for wildlife.

19. Additional mitigation for losses associated with construction of this and other stages of the project will be provided with the construction of Fish and Wildlife features on the Minnesota Valley National Wildlife Refuge. The features include the construction of an outlet control structure for Chaska Lake and the construction of a 19 acre moist soil unit just to the east of Chaska Lake. The outlet control structure will provide the capability to manipulate water levels on the lake to control aquatic vegetation. The moist soil unit will be managed to provide feeding habitat for waterfowl. The area will be created by diking a 19 acre site that is currently cropland. The system will consist of two cells that can be flooded to a depth of about 2 feet and managed independently.

20. While preliminary designs of the above features have been developed, delays in the acquisition of surveys have delayed detailed design studies of specific features. Therefore, detailed design of the mitigation features will be done separately. The construction of the mitigation features will be done concurrently with construction of this stage of the project or it may be constructed earlier by a separate construction contract.

21. Design departures from what was described in the General Design Memorandum have been evaluated. The proposed changes would not result in any substantive changes in impacts from what was described in the Final Supplement to the Final Environmental Impact Statement, dated August 1982 or the Final Supplement II, dated February 1985. Therefore, additional NEPA documentation is not necessary.

#### CULTURAL RESOURCES

22. In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, the National Register of Historic Places has been consulted. A standing structure survey of Carver County conducted for the Minnesota State Historic Preservation Office in 1978 recorded 23 Historic National Register buildings and one National Register district in the City of Chaska. As of 13 December 1989, there are no sites listed on the National Register that will be affected by the proposed project. The buildings to be removed along the existing levee in connection with its upgrade have been evaluated by the staff of the Minnesota State Historic Preservation Office (MN SHPO) as being not eligible for listing on the National Register of Historic Places. As a result, there will be no affect on significant historic properties if any of the buildings are removed as proposed (per letter dated February 11, 1991 from MN SHPO).

23. The portion of the proposed Stage 4 levee along Courthouse Lake and East Creek was inventoried for cultural resources in 1985 as part of a project-related geomorphological and archeological investigation of the Minnesota River floodplain at Chaska. No cultural resources were encountered. In 1982, the Minnesota State Historic Preservation Office determined that the existing emergency levee along the south side of Chaska did not need a cultural resources survey as the project as then proposed would only affect extensively disturbed areas within the 10 feet of either side of the levee. Regardless,

in 1987, the floodplain area riverward of the existing emergency levee opposite Elm Street was surveyed for cultural resources as part of the Stage 2 Chaska Creek Diversion Stilling Basin then proposed for this area. No prehistoric or historic archeological resources were observed.

24. The remaining portions of Stage 4 of the Chaska Flood Control Project are scheduled for archeological and geomorphological investigation in the Spring of 1991. Contracting constraints prevented their survey in the Fall of 1990 as originally planned. The areas yet to be checked for cultural resources include the proposed stretch of levee northeast of Courthouse Lake and East Creek, the area where the existing emergency levee on the south side of Chaska between Hickory Street and Pine Street will be moved riverward, and the moist soil units on the Minnesota Valley National Wildlife Refuge east of Chaska Lake. The archeological survey will be coordinated with the Minnesota State Historic Preservation Office and in the case of the moist soil units, the U.S. Fish and Wildlife Service.

25. As presently proposed, borrow for levee construction will come from an existing commercial borrow area. If additional or alternate borrow areas are chosen for use with this project, they will have an archeological survey conducted at them prior to their use. The need for and results of such surveys will be coordinated with the Minnesota State Historic Preservation Office.

#### CONSTRUCTION MATERIALS

##### GENERAL

26. Concrete aggregate, berm and pervious fill and topsoil can be obtained from commercial sources in the area. See appendix C for additional discussion on construction materials.

##### LEVEE FILL (Sheet 1)

27. Impervious levee fill will be obtained from a commercial borrow area located about a mile from the project. This is the same borrow area provided by Chaska for the Stage 2 levee.

##### RIPRAP AND BEDDING

28. Riprap and bedding of adequate quality can be obtained from existing quarries located within 40 miles of Chaska.

#### CONSTRUCTIBILITY

29. Appendix F contains a discussion on the construction aspects of this project.

## REAL ESTATE REQUIREMENTS

30. The City of Chaska will provide, without cost to the United States, and as generally provided by the Local Cooperation Agreement, all real estate interests, to include borrow and disposal areas, required for the construction, operation, and subsequent maintenance of the project. The City will also comply with all provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646, as amended).

31. This stage of the Chaska Flood Control project will require the use of 58 acres of land, besides borrow and disposal areas, for project construction and maintenance. Real estate interests will be acquired from and/or credited to about 45 separate ownerships. Estates needed will be fee title, permanent easements, and temporary easements during construction. The following real estate costs were determined from right-of-way drawings and acreages provided by ED and include all reasonable amounts for acquisition of land and improvements, damages, and uneconomic remnants. Fee simple title has been designated for acquisition in lieu of permanent levee easements wherever proposed recreation trail features appear.

32. The costs are for all interests in land, improvements that include 8 residences and 18 garages or utility buildings privately owned, and damages to remaining property. A total of 45 separate ownerships are estimated.

Fee simple title (45) acres	\$1,100,000	
Permanent levee easements (6 acres)	125,000	
Temporary construction area easements (7 acres)	<u>68,000</u>	
Subtotal (58 acres)		\$1,293,000
Replacement housing/moving costs under Public Law 91-646, as amended		188,300
Administrative acquisition costs		
Local sponsor	55,000	
Federal	<u>28,200</u>	
Total administrative costs		<u>83,200</u>
Total contingencies		299,500
Total real estate estimate		\$1,864,000

## MEASURES FOR PHYSICAL SECURITY

33. Hatches at the gatewells and pump station would be secured with locks to prevent the public from entering and the pump station door will be lockable. The gatewells will have railings around them to prevent falls from them. Public access to the levee by vehicles will be prevented by removable guard post where roads cross the levee.

## CORROSION MITIGATION

34. There is no evidence that corrosion due to the water and soils in the Chaska area is a problem. Therefore, no corrosion mitigation is planned.

## WATER QUALITY

35. The fill materials placed in the river channel would be uncontaminated materials obtained from approved quarries and borrow areas. This should insure that water quality standards would not be violated because of project-related activities. Although some minor temporary increase of turbidity would occur during construction, levels of turbidity would return to normal after construction. No long term ponding of water, change of runoff characteristics, or operational procedures that would effect water quality would be associated with the project.

36. The provisions of Section 404 of the Clean Water Act have been met with the submission of the EIS Supplement, including a Section 404(b)(1) Evaluation, to Congress on 26 April 1982. The provisions of Section 404 were further met with the submission of the EIS Supplement No. 2, including a Section 404(b)(1) Evaluation in April 1985. The final EIS for Supplement No. 2 was filed in May 1985.

## COST ESTIMATE

37. The cost estimate in this DM is based on current price levels and reflects recent prices for similar work done in the St. Paul District. The following table (Table 1) presents a cost estimate for Chaska, Stage 4 indexed to 1 October 1991 price levels and a comparison of the cost estimate with the current approved PB-3 estimate. Also shown is an estimate of the local share of the costs. The cost sharing is in accordance with the 1986 Water Resources Development Act (Public Law 99-662). Appendix G contains the detailed cost estimate for this project.



Table 1  
Summary Comparison of Estimated First Costs

Item	Current Approved Estimate From PB-3 (1 October 1990)	Revised Estimate This DM (1 October 1991)
First Cost		
Land and Damages	\$1,102,000	\$2,060,000
Relocations		
Federal	0	0
Non-Federal	18,000	553,000
Levees and Floodwalls	3,121,000	5,477,000
Pumping Plants	555,000	648,000
Recreation Facilities	130,000	109,000
Planning, Engineering and Design	841,000	1,733,000
Construction Management	218,000	375,000
Total First Costs	5,985,000	10,955,000
Federal/Non-Federal		
Federal First Cost		
Flood Control	4,450,000	8,177,000
Recreation	77,000	66,000
Total	\$4,527,000	\$8,243,000
Non-Federal First Cost		
Flood Control	1,381,000	2,646,000
Recreation	77,000	66,000
Total	\$1,458,000	\$2,712,000

38. The difference in project first cost (an increase of \$4,970,000) between this DM cost estimate (\$10,955,000) and the current approved PB-3 (\$5,985,000) is attributable to the following:

- a. Price levels: +\$202,000
- b. Lands and Damages: +913,000
  - (1) Increase due to cost of impervious borrow from commercial source. +175,000
  - (2) Increase based on refined design and additional acquisition +888,000
  - (3) Decrease due to realignment of levee between stations 60+00 and 70+00 -150,000
- c. Relocation: +534,000
  - (1) Increase due to the addition of the North, Beech, Cedar, and pedestrian ramps over the levee +155,000

(2)	Increase due to the addition of a sanitary sewer, force main, lift station and manholes	+340,000
(3)	Increase due to the addition of miscellaneous utility modifications	+ 39,000
d.	Levees and Floodwalls:	+2,228,000
(1)	Increase due to increase in the volume of impervious fill required	+243,000
(2)	Increase due to revision in unit cost of impervious fill	+ 63,000
(3)	Increase due to revision in unit cost of relief wells	+402,000
(4)	Increase due to increase in number of relief wells	+132,000
(5)	Increase due to the addition of dewatering cost	+445,000
(6)	Increase due to the addition of riprap and bedding	+346,000
(7)	Increase due to the redesign of the outlets	\$229,000
(8)	Increase due to an increase in the number of manhole and inlets	+190,000
(9)	Increase due to the addition of a traffic control cost	+104,000
(10)	Increase due to the addition of clearing and grubbing	+ 74,000
(11)	Increase due to the additional landscaping	+ 40,000
(12)	Increase due to miscellaneous changes in unit costs, quantities contingencies and design details	+210,000
(13)	Decrease due to realignment of levee between stations 60+00 and 70+00	- 50,000
(14)	Decrease due to changing pump station location from Pine St. to Oak St.	-200,000

- e. Pumping Plant: +70,000
  - (1) Increase due to the addition of a parking lot and other site work + 16,000
  - (2) Increase due to more detailed design details + 54,000
- f. Recreation Facilities: -26,000
  - (1) Decrease due to deletion of bituminous surfacing between stations 0+00 and 29+00 - 26,000
- g. Planning, Engineering, and Design: +882,000
  - (1) Increase due to increase in construction cost +659,000
  - (2) Increase due to a reanalysis of the remaining design work required +223,000
- h. Construction Management: +150,000
  - (1) Increase due to increase in construction cost +150,000

# CURRENT BENEFIT - COST ANALYSIS

39. The current Benefit/Cost analysis is based on the procedures used for updating project budgets. The last approved economic analysis of the Chaska Flood Control project was for the GDM dated February 1984 and is in October 1983 prices. Project first costs (\$38,700,000 Oct 91) have been deflated from October 1991 price levels to October 1983 price levels (\$32,244,000 Oct 83) using the ENR construction costs index. The factor is 0.8331. Interest during construction has been calculated using the same method as presented in the GDM report in which interest during construction is discontinued after completion of each stage.

TABLE 1 BENEFIT/COST ANALYSIS  
(All figures are in October 1983 price levels)

<u>Federal</u>	
First Cost	24,169,000
Interest During Construction	2,536,100
Investment Cost	26,705,100
Annual Costs	2,342,000
<u>Non-Federal</u>	
First Costs	8,075,000
Interest During Construction	658,700
Investment Cost	8,733,700
Annual Costs	765,900
Annual Operation and Maintenance	42,000
<u>Total Investment Cost</u>	35,438,800
Total Annual Cost	3,149,900
8 3/4% 100 year project life	
Int & amort factor (.0877)	
Annual Benefits (1)	
Flood Control	2,232,000
Recreation	28,000
Total	2,260,000
Benefit Cost Ratio	0.72

(1) A cursory benefit analysis performed since the approved economic analysis indicates there is a potential for quantifying additional benefits. Additional benefits will be determined by the St. Paul District.

## SCHEDULE FOR DESIGN AND CONSTRUCTION

### DESIGN

40. Schedules for design and construction are based on the President's budget for Fiscal Year 1992. Plans and specifications are scheduled for completion in August 1992.

### CONSTRUCTION

41. A continuing contract for Minnesota River Levees construction is scheduled for award in January 1993. Completion of construction is scheduled for August 1994.

### FUNDING SCHEDULE

42. On the basis of the revised estimate for this DM and the current schedule presented in the President's FY-92 budget for completion of the project, the Federal funds required (by fiscal year) for construction are as follows:

- a. Fiscal Year 1993 - \$3,500,000
- b. Fiscal Year 1994 - \$3,830,000

### OPERATION AND MAINTENANCE

43. Under the terms of the Local Cooperation Agreement, the local sponsor will be responsible for the operation and maintenance (O&M) of the project. An O&M manual will be provided to the local sponsor prior to final acceptance of the project by the local sponsor.

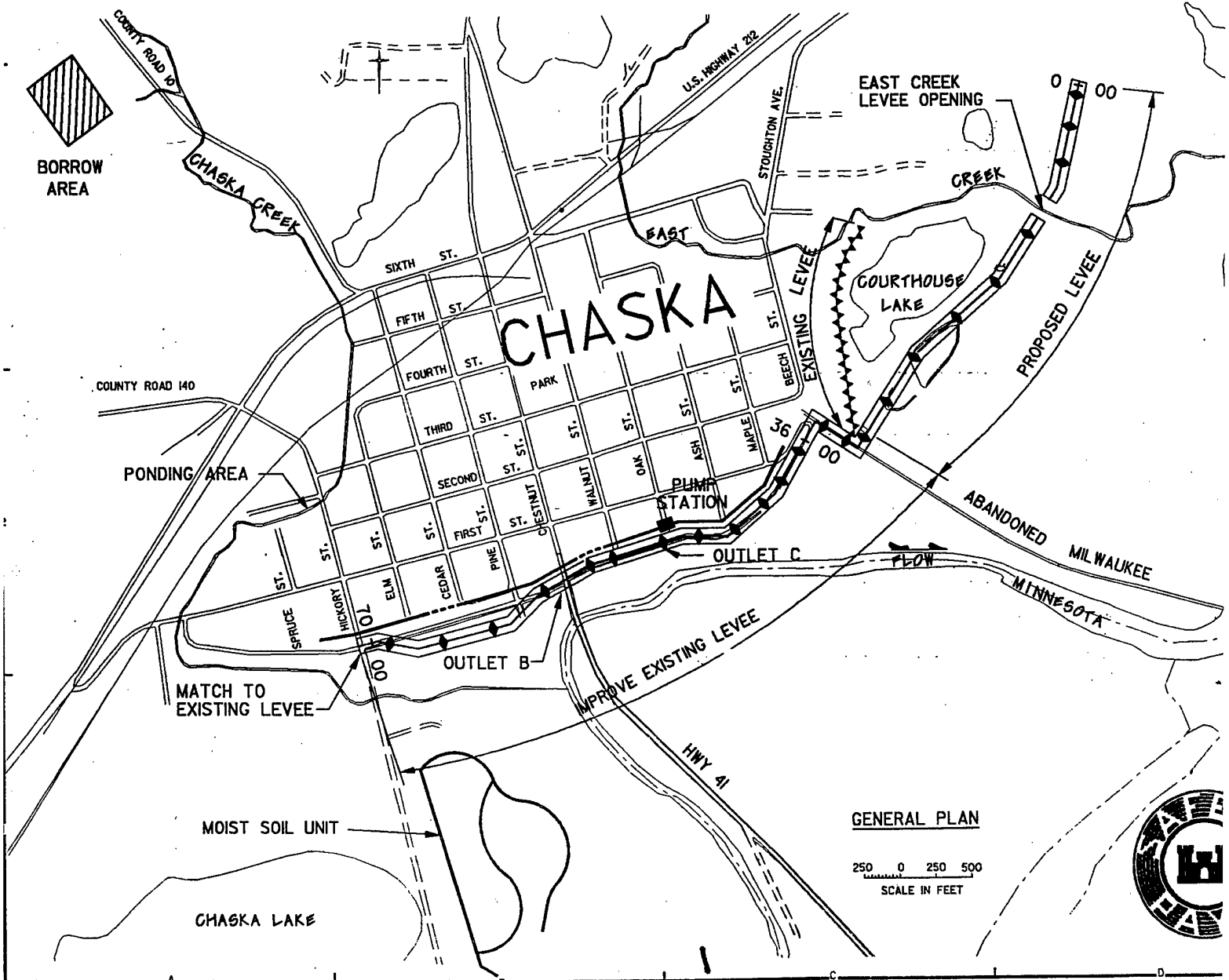
### RECOMMENDATION

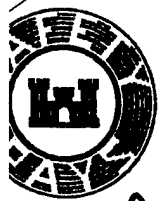
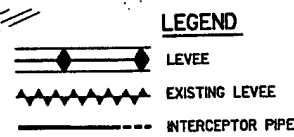
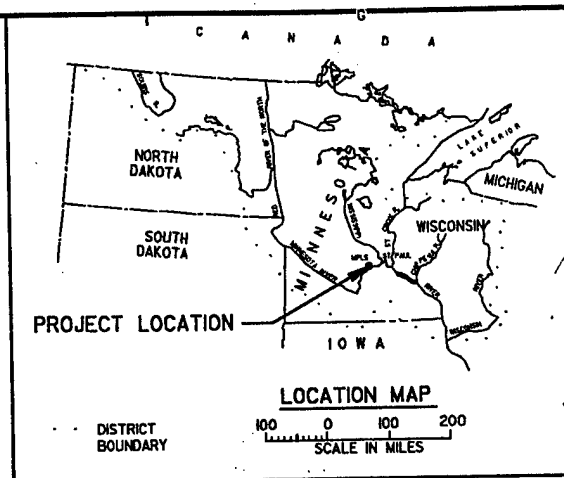
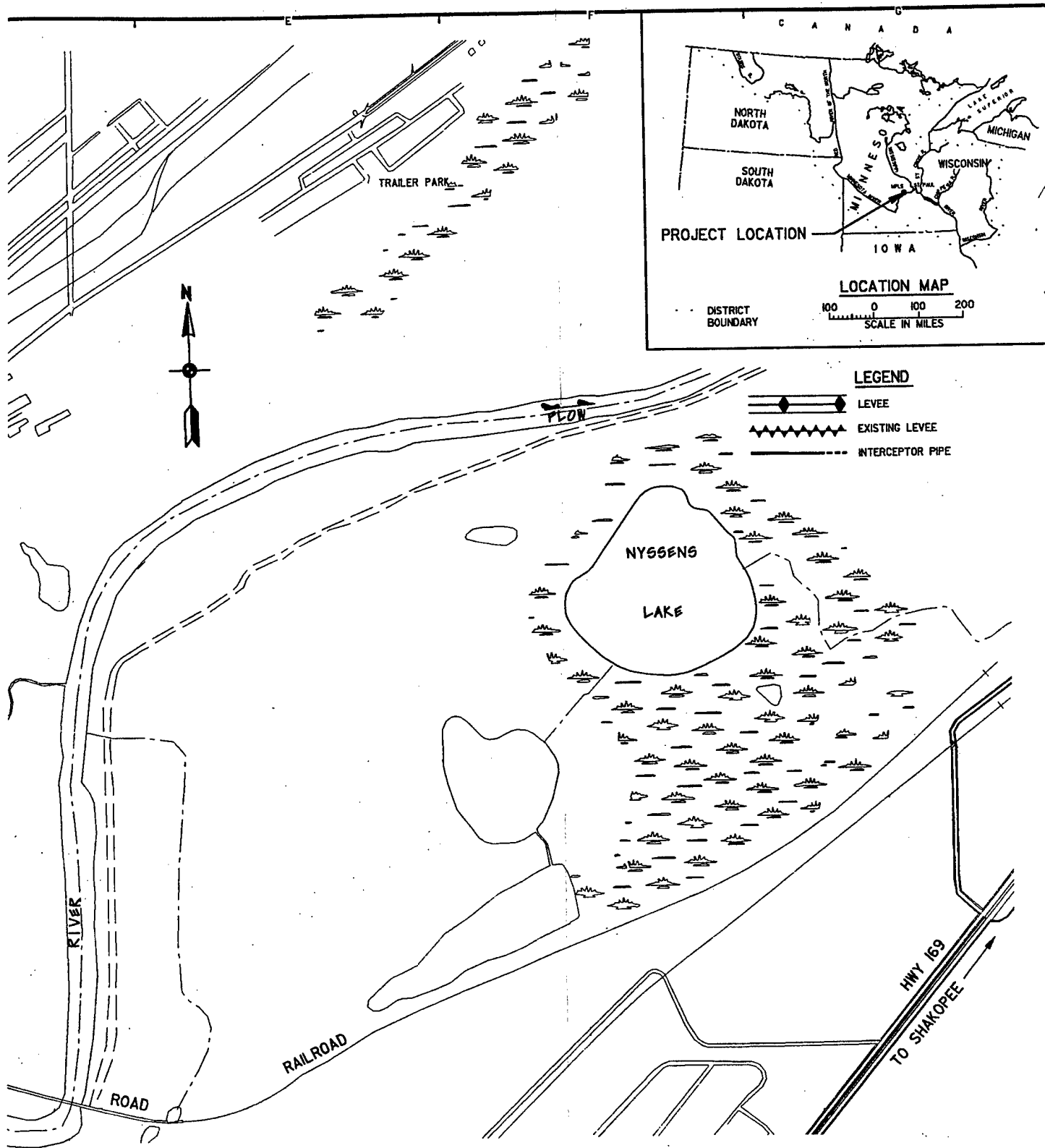
44. I recommend the approval of the plan for Stage 4, Minnesota River Levees, at Chaska, Minnesota, flood control project as presented in this DM.

ROGER L. BALDWIN  
Colonel, Corps of Engineers  
District Engineer

DRAWING INDEX		
DRAWING NO.	SHT.	DESCRIPTION
PROJECT LOCATION		
M34-CH-R-5/200	1	LOCATION MAP, GENERAL PLAN, AND DRAWING SCHEDULE
DRAINAGE AND LEVEES		
M34-CH-R-5/201	2	PLAN AND PROFILE STA. 0+00 TO 10+00
M34-CH-R-5/202	3	PLAN AND PROFILE STA. 10+00 TO 19+50
M34-CH-R-5/203	4	PLAN AND PROFILE STA. 19+50 TO 28+90
M34-CH-R-5/204	5	PLAN AND PROFILE STA. 28+90 TO 36+70
M34-CH-R-5/205	6	PLAN AND PROFILE STA. 36+70 TO 45+50
M34-CH-R-5/206	7	PLAN AND PROFILE STA. 45+50 TO 55+50
M34-CH-R-5/207	8	PLAN AND PROFILE STA. 55+50 TO 66+00
M34-CH-R-5/208	9	PLAN AND PROFILE STA. 66+00 TO 76+50
M34-CH-R-5/209	10	PLAN AND PROFILE STA. 76+50 TO 82+50
M34-CH-R-5/210	11	LEVEE CROSS SECTIONS
M34-CH-R-5/211	12	LEVEE CROSS SECTIONS
M34-CH-R-5/212	13	LEVEE CROSS SECTIONS
M34-CH-R-5/213	14	PROFILE, PEDESTRIAN BRIDGE APPROACH
M34-CH-R-5/214	15	PROFILE, SANITARY OUTFALL PIPE
INTERIOR DRAINAGE		
M34-CH-R-5/215	16	MANHOLES AND INLETS
M34-CH-R-5/216	17	MANHOLES, PLAN AND SECTIONS
M34-CH-R-5/217	18	MANHOLES, PLAN AND SECTIONS
M34-CH-R-5/218	19	INLETS - PLANS, SECTIONS, AND SCHEDULE
M34-CH-R-5/219	20	RELIEF WELLS, SECTIONS AND SCHEDULE
M34-CH-R-5/220	21	OUTLET C, PROFILES
M34-CH-R-5/221	22	OUTLET B, PROFILE

DRAWING INDEX		
DRAWING NO.	SHT.	DESCRIPTION
M34-CH-R-5/222	23	GATEWELL B, PLAN AND SECTIONS
M34-CH-R-5/223	24	GATEWELL C, PLAN AND SECTIONS
PUMPING STATION		
M34-CH-R-5/224	25	SITE DRAWING
M34-CH-R-5/225	26	SITE PLAN AND PERSPECTIVE SKETCHES
M34-CH-R-5/226	27	LAYOUT PLANS
M34-CH-R-5/227	28	LAYOUT SECTIONS
M34-CH-R-5/228	29	LAYOUT SECTIONS & DETAILS
M34-CH-R-5/229	30	3 PUMP CONTROL DIAGRAM
RECREATION		
M34-CH-R-5/230	31	COURTHOUSE LAKE TRAIL





SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET, AS INDEXED ON THIS SHEET.

APPROVAL RECOMMENDED BY:

*Chris P. [Signature]*  
CHIEF ED-D BRANCH

*Helmer [Signature]*  
CHIEF ED-GH BRANCH

*Robert L. [Signature]*  
CHIEF ENGINEERING DIVISION

APPROVED BY:

*[Signature]*  
COL... CORPS OF ENGINEERS

*[Signature]*  
ENGINEER

*[Signature]*  
CHIEF SPECS. & TECH. SUPPORT SECTION

*[Signature]*  
CHIEF GENERAL ENGINEERING SECTION

*[Signature]*  
CHIEF STRUCTURAL SECTION

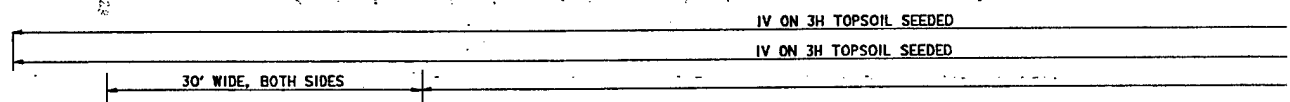
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CHIEF HYDRAULICS SECTION

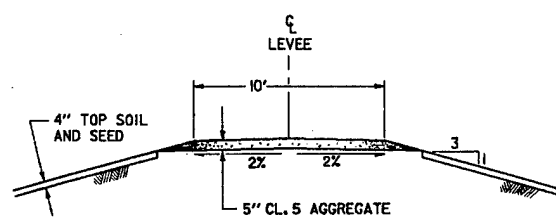
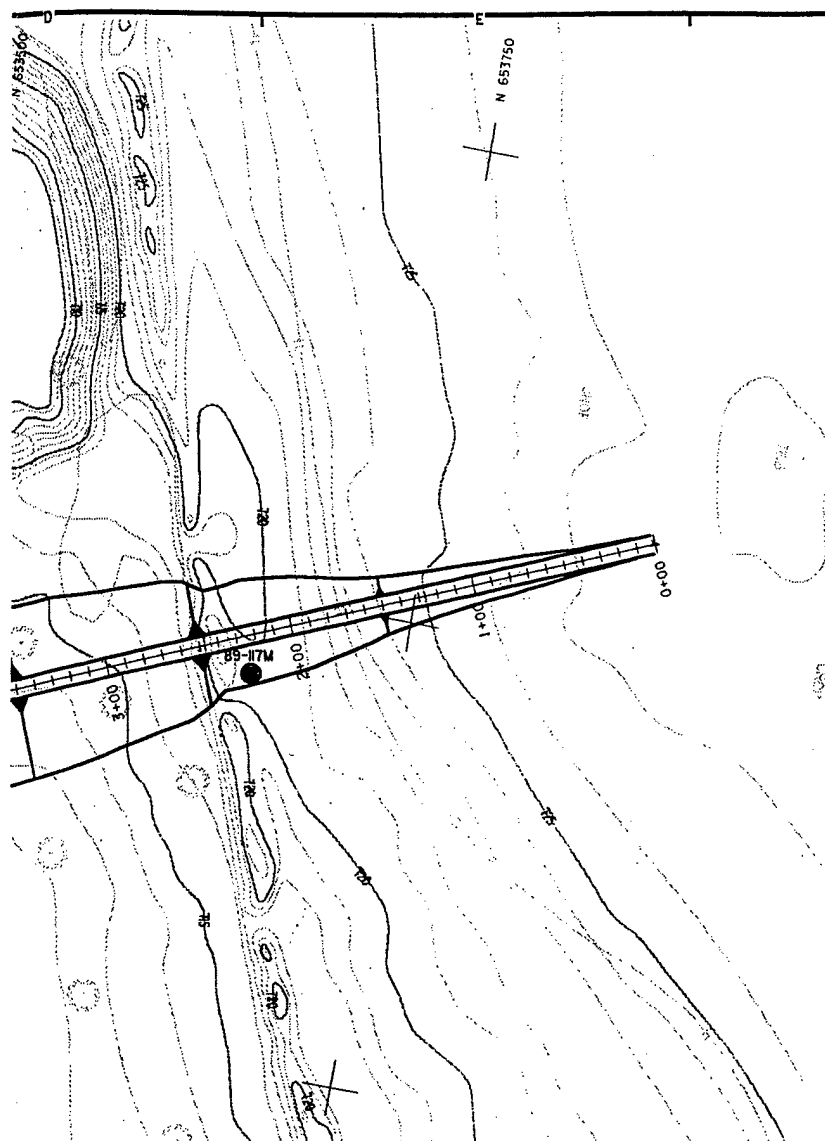
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*[Signature]*  
CHIEF GEOTECHNICAL DESIGN SECTION

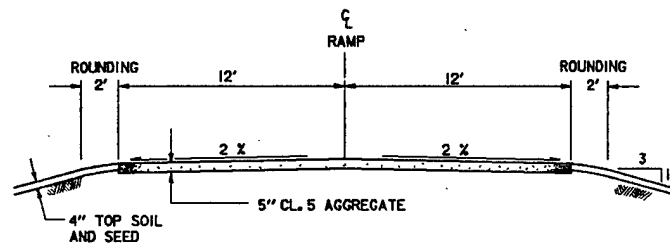
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DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA			
DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA <b>CHASKA PROJECT DRAINAGE &amp; LEVEE</b> LOCATION MAP, GENERAL PLAN AND DRAWING INDEX			
DESIGNED: R.J.M.		SHT 1	
CHECKED: J.J.G.		OF 31	
DRAWN: R.J.M.-T.J.			
DESIGNED: W.J.M.-J.R.C.			
CHECKED:			
DATE: MARCH 1991			
SPEC NO:			
CAD FILE NAME: MNICP000.DGN		DRAWING NUMBER: M34-CH-R-5/200	





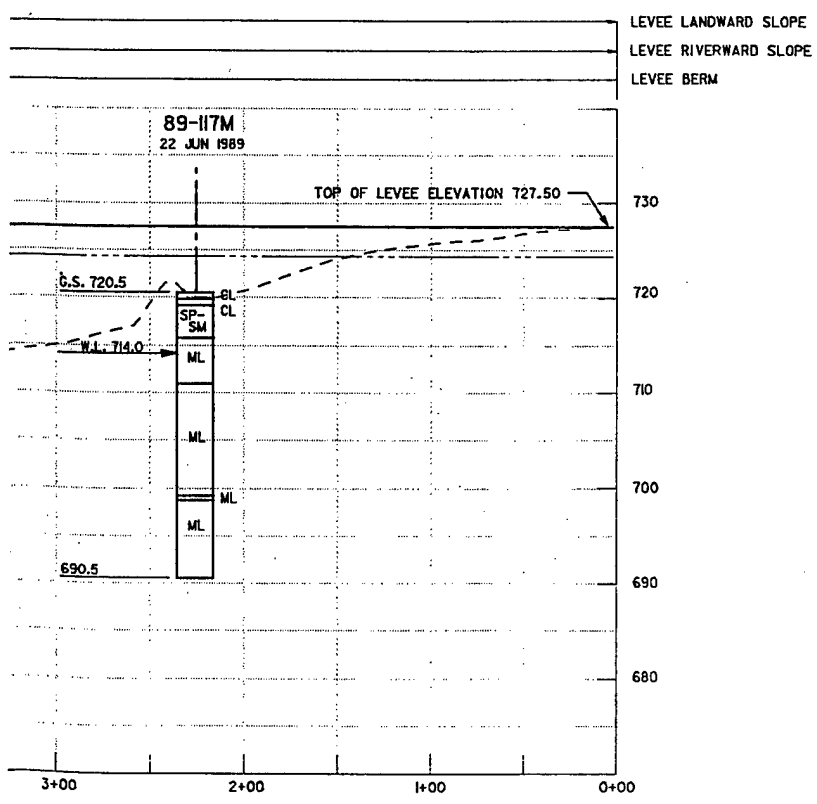


**TYPICAL SECTION**  
STA. 0+00 TO STA. 28+50  
TRAIL ON TOP OF LEVEE  
NO SCALE



**TYPICAL SECTION**  
TWO LANE RAMP

**PLAN VIEW**

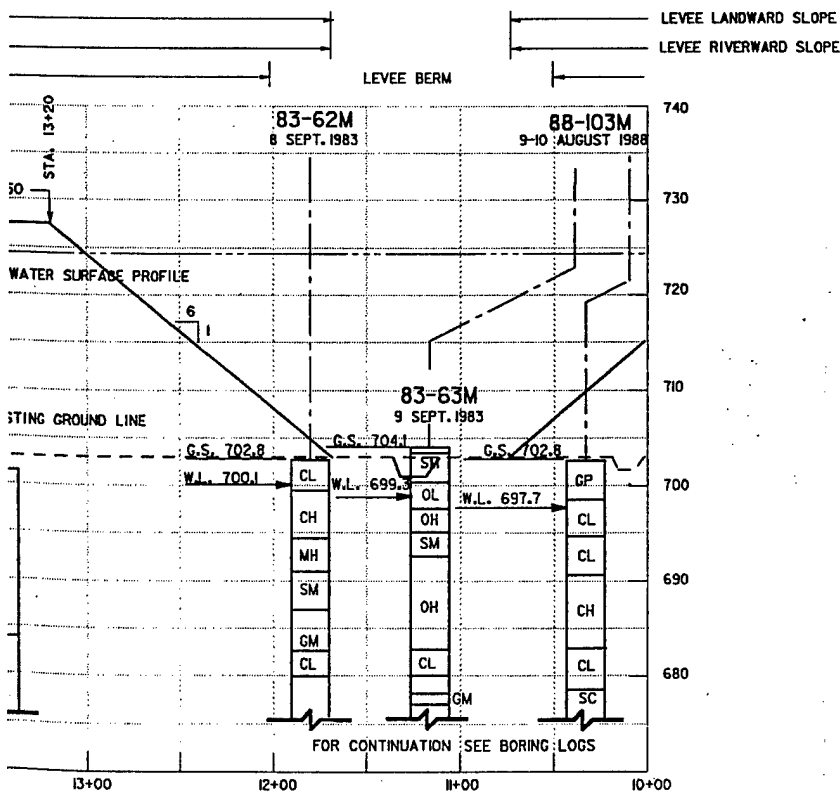
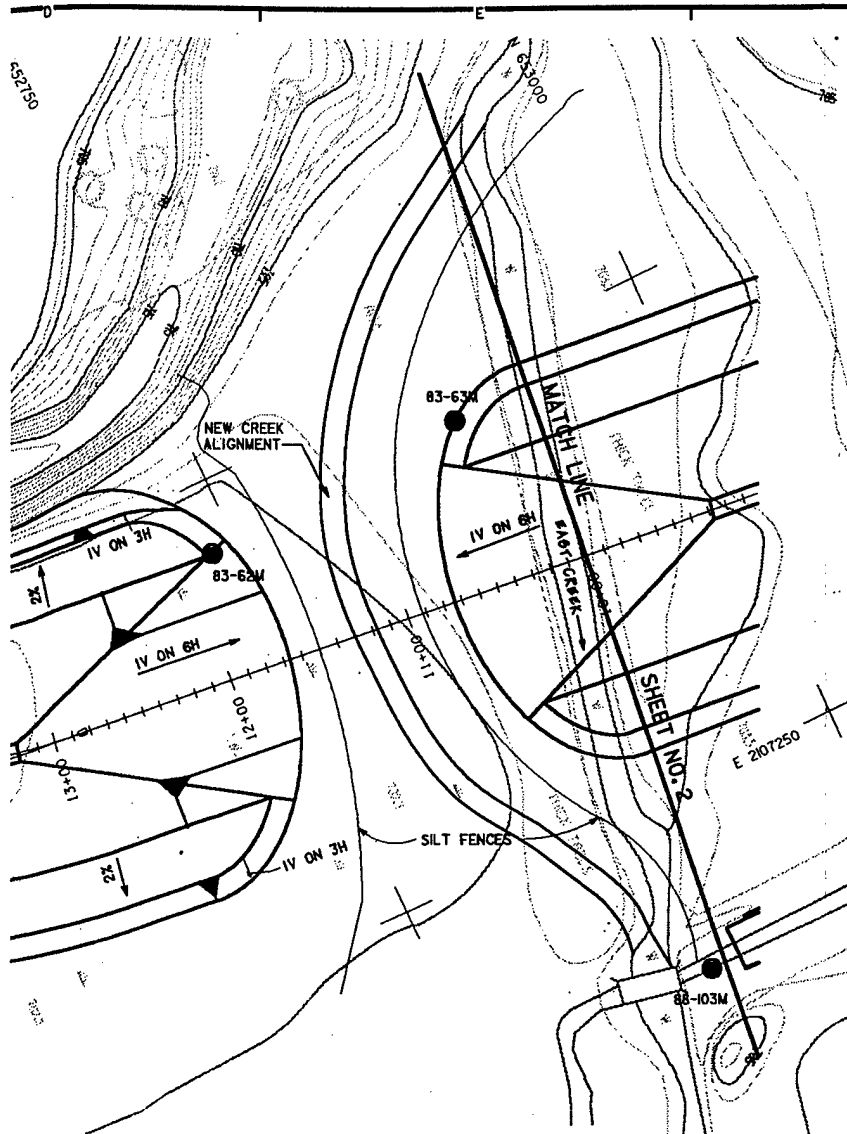


**NOTES:**

1. ELEVATIONS REFER TO M.S.L. (929 ADJ.)
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA</p>			
DESIGNED: CHECKED: DRAWN: DESIGNED: CHECKED: DATE:	R.J.M. J.J.C. T.J. R.J.M. J.R.C. J.W.M.	<b>CHASKA PROJECT</b> <b>DRAINAGE &amp; LEVEES</b> PLAN & PROFILE STA. 0+00 TO 10+00		CAD FILE NAME:	DRAWING NUMBER:
				MNIPOOL.DGN	M34-CH-R-51/201
DATE: MARCH 1991		SPEC NO: DACW37-90-B-0000		SHT 2	OF 31

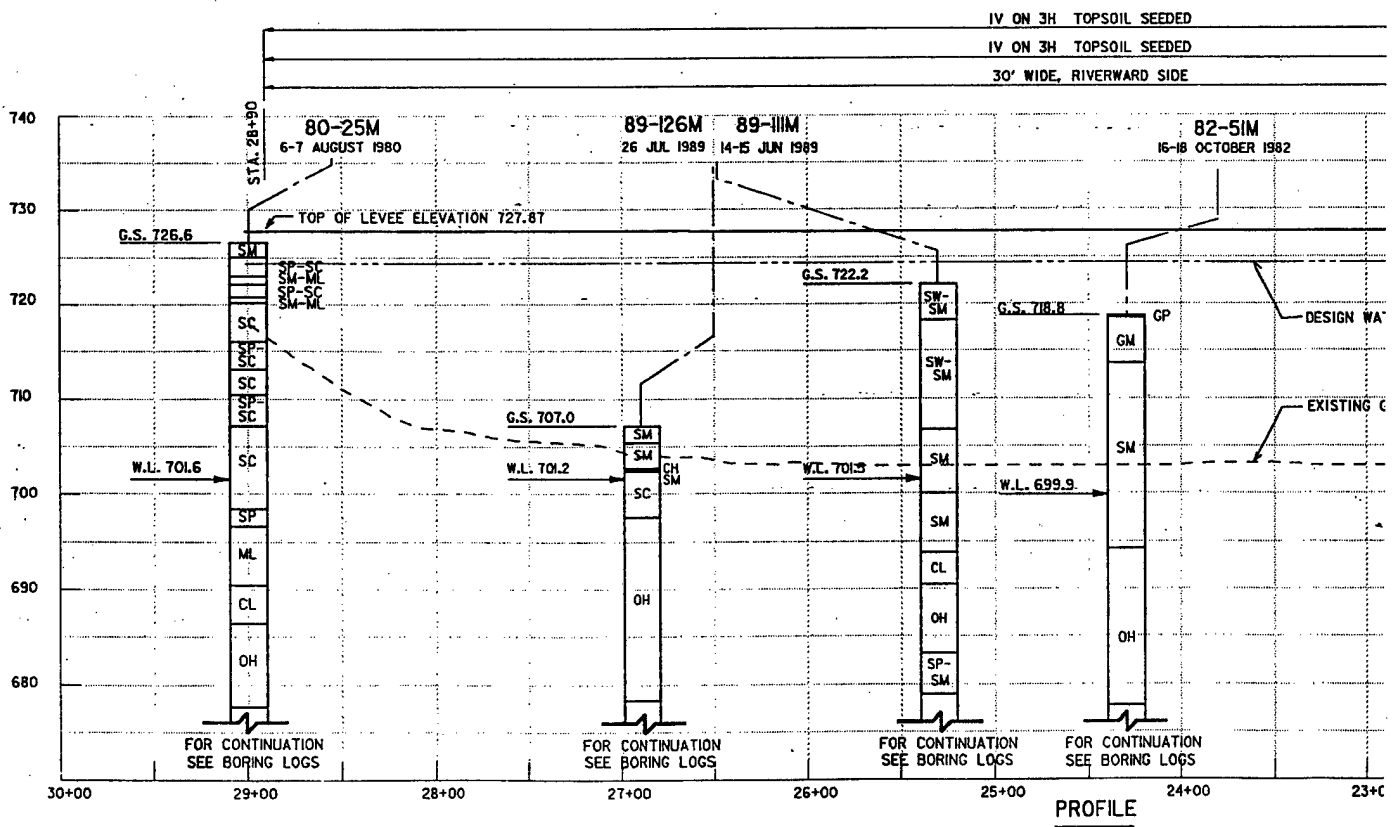
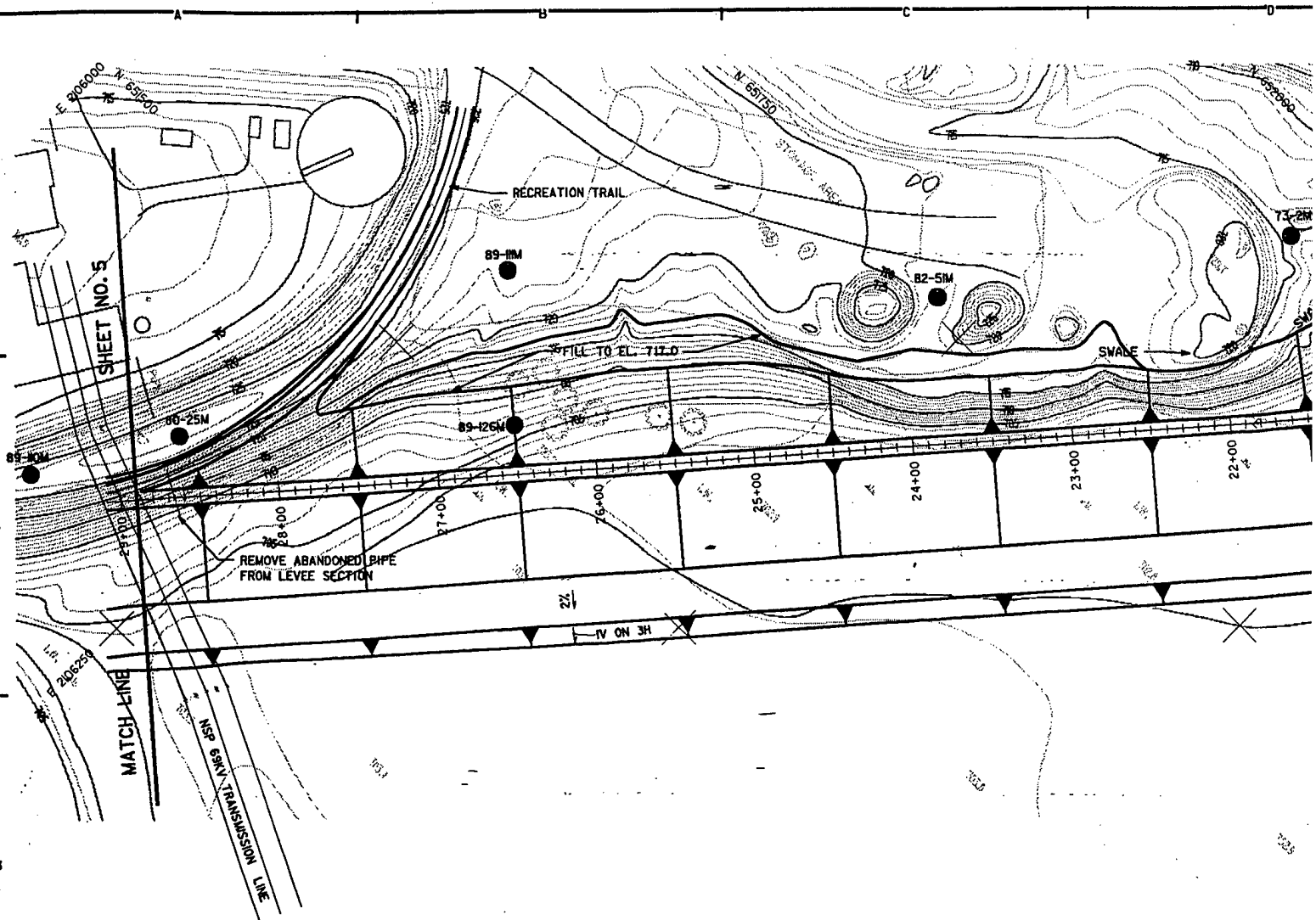


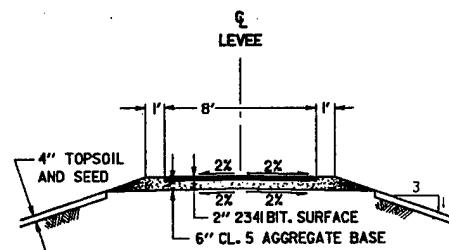


# NOTES:

1. ELEVATIONS REFER TO M.S.L. (1929 ADJ.)
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.

SYMBOL	DESCRIPTION	DATE	APPROVAL
<p><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA</p>	
<p>DESIGNED: R.J.M.</p>		<p>DRAINAGE &amp; LEVEES PLAN &amp; PROFILE STA. 10+00 TO 19+50</p>	
<p>CHECKED: J.J.G.</p>		<p>CAD FILE NAME: MNIOP002.DGN</p>	
<p>DRAWN: T.J. R.J.M.</p>		<p>DRAWING NUMBER: M34-CH-R-5/202</p>	
<p>DESIGNED: J.R.C.</p>		<p>SHT 3</p>	
<p>CHECKED:</p>		<p>DATE: MAR 1991</p>	
<p>DATE:</p>		<p>SPEC NO:</p>	





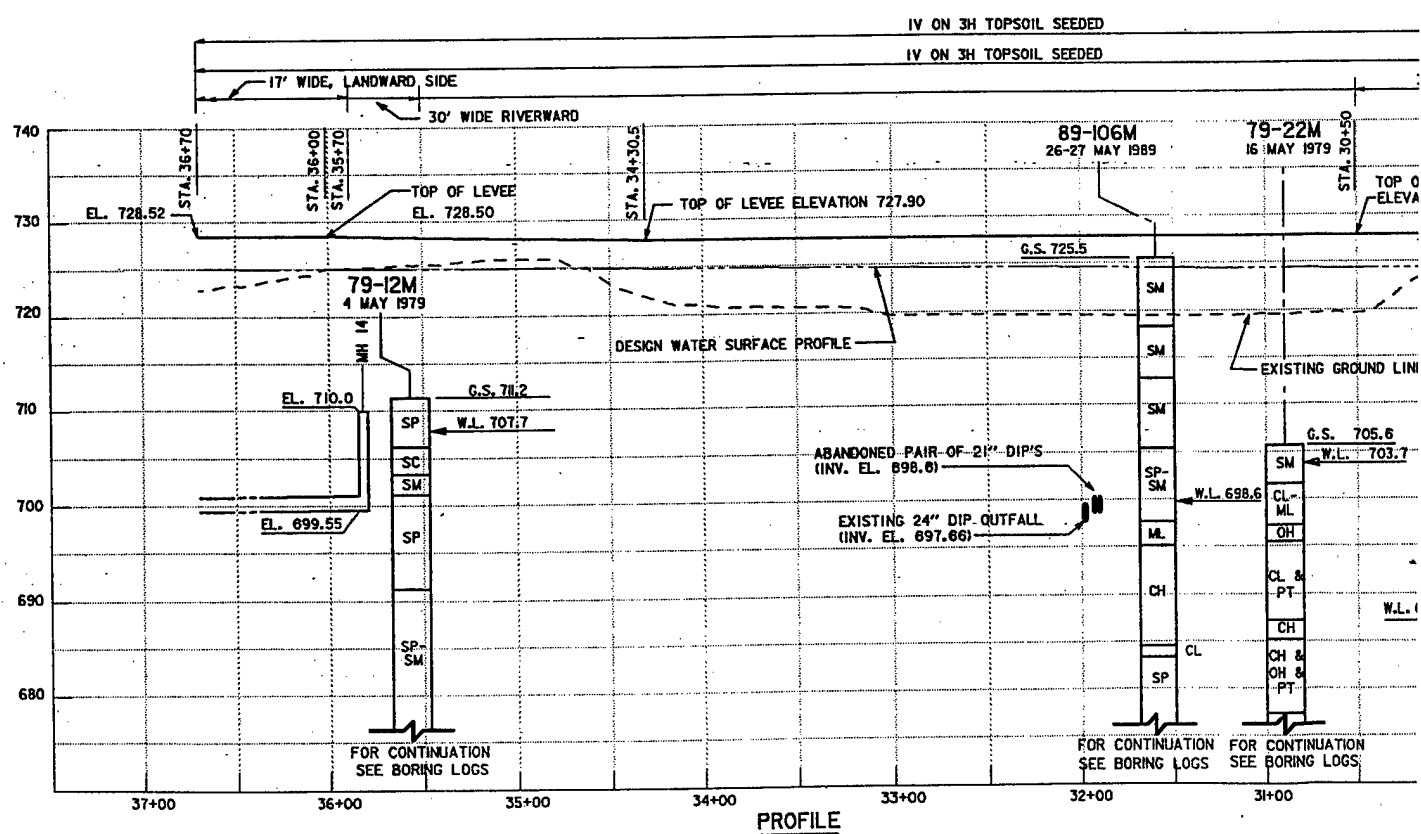
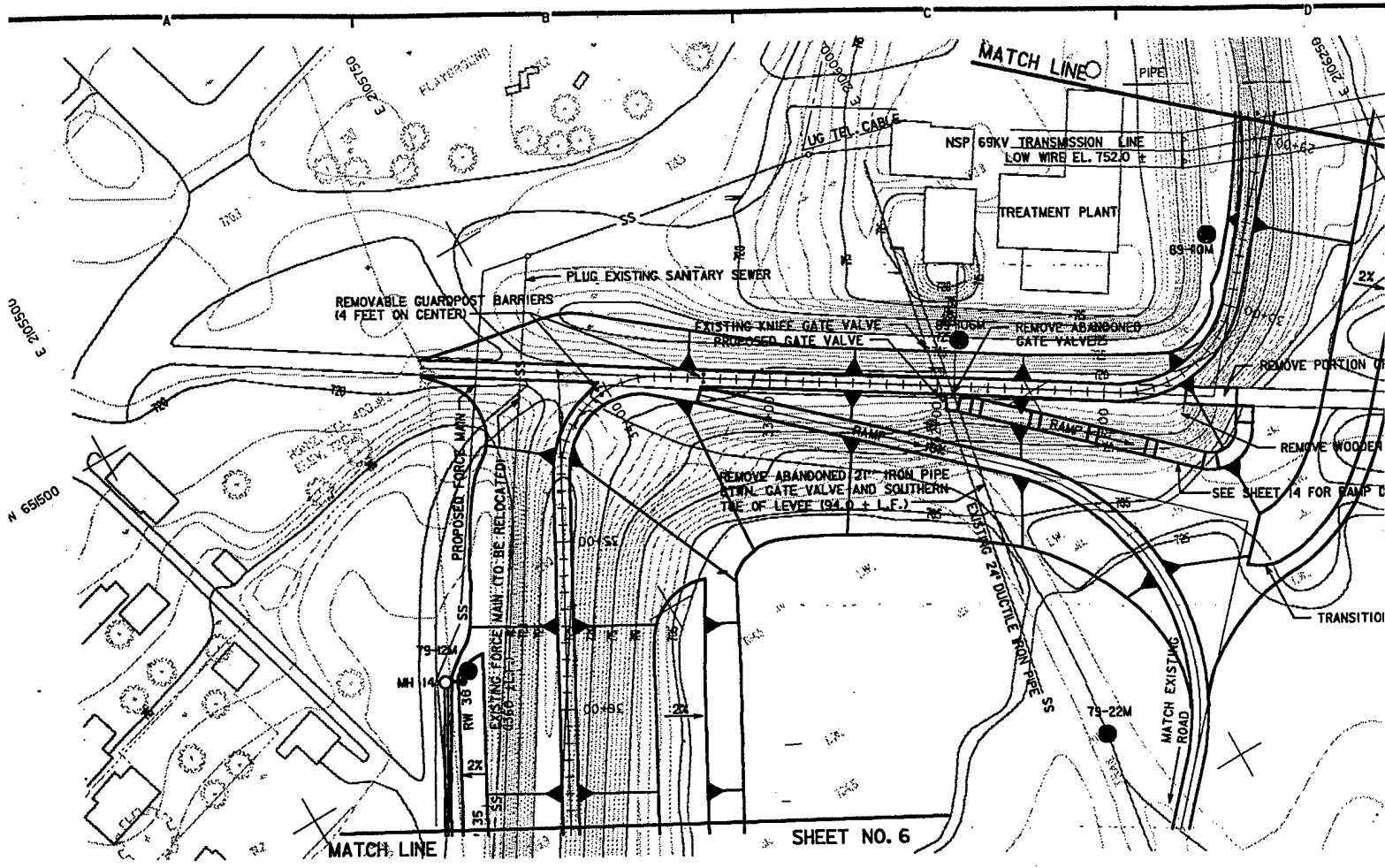
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STA. 28+50 TO STA. 71+17  
TRAIL ON TOP OF LEVEE  
NO SCALE

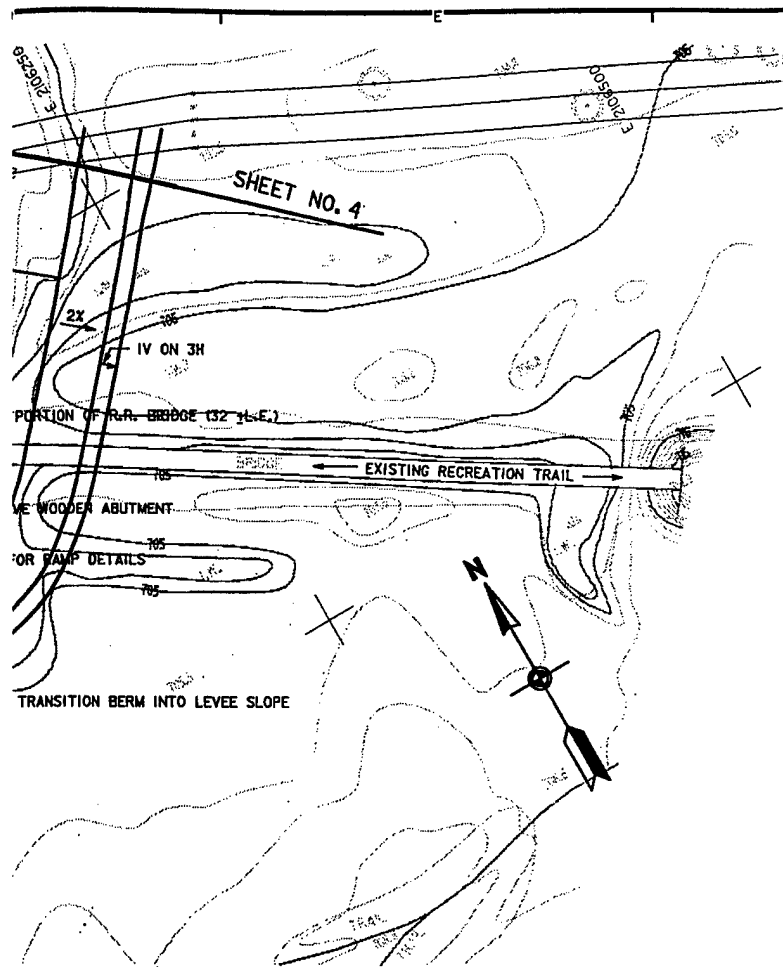


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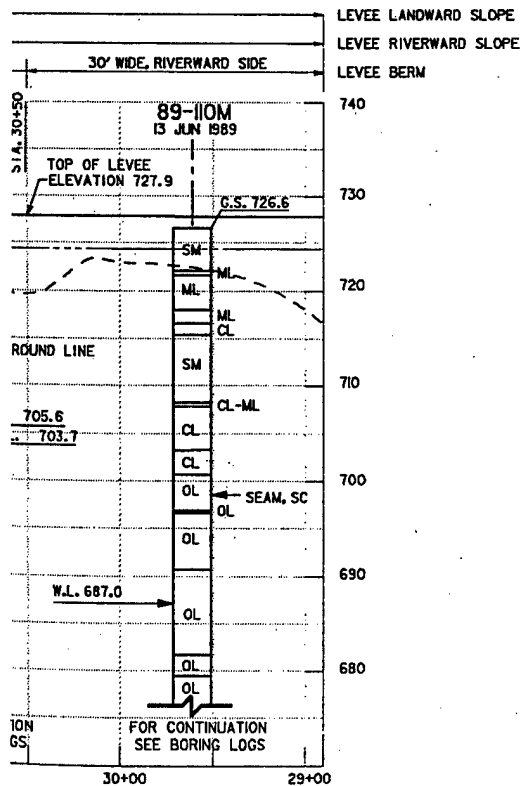
1. ELEVATIONS REFER TO M.S.L. (1929 ADJ.)

SYMBOL	DESCRIPTION		DATE	APPROVAL
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AE APPROVING OFFICIAL:  _____		DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER <b>CHASKA PROJECT</b> CHASKA, MINNESOTA		
ED-D	DESIGNED: R.J.M.	<b>DRAINAGE &amp; LEVEES</b> PLAN & PROFILE STA. 19+50 TO 28+90		
	CHECKED: J.J.G.			
	DRAWN: T.C. - R.J.M.			
ED-CH	DESIGNED: J.R.C.			
	CHECKED:			
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	SPEC NO:	<b>M34-CH-R-5/203</b>		OF 3





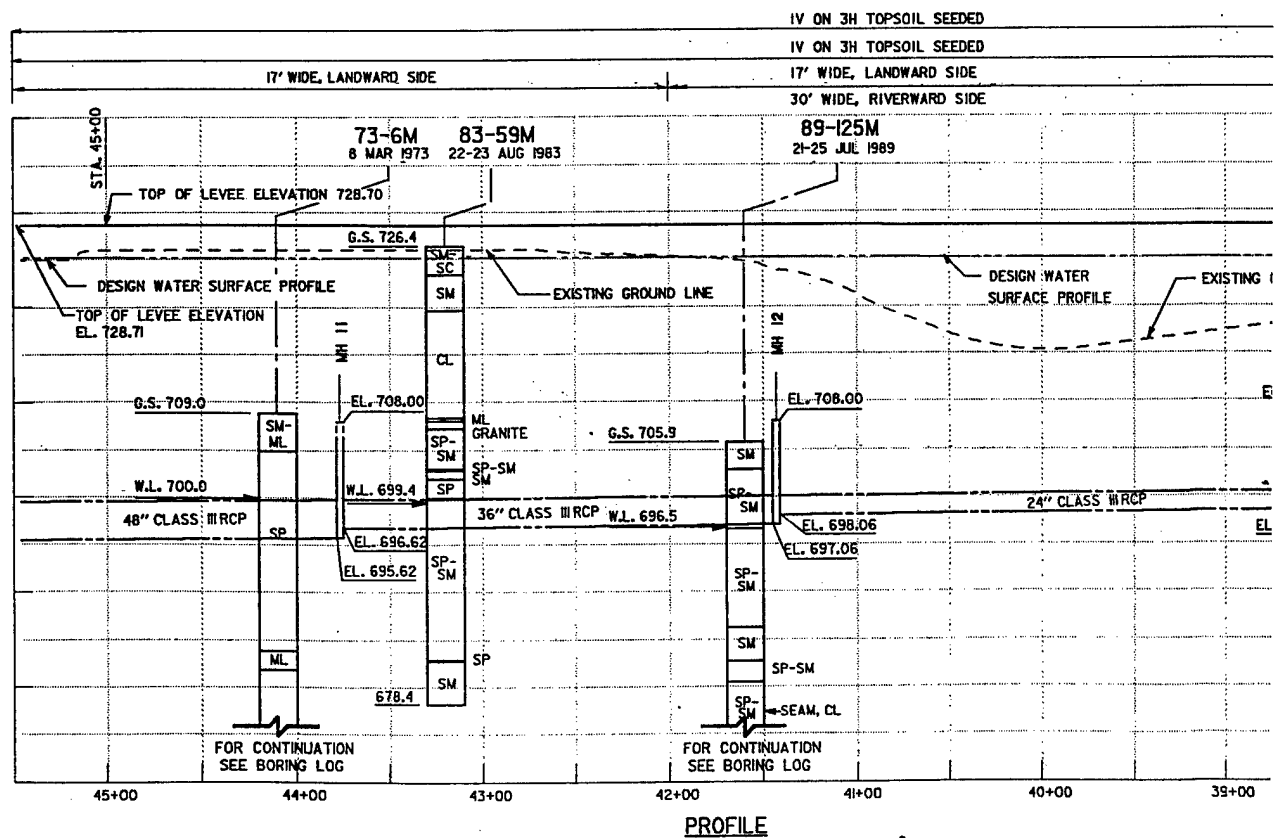
PLAN VIEW



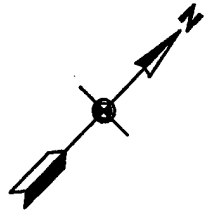
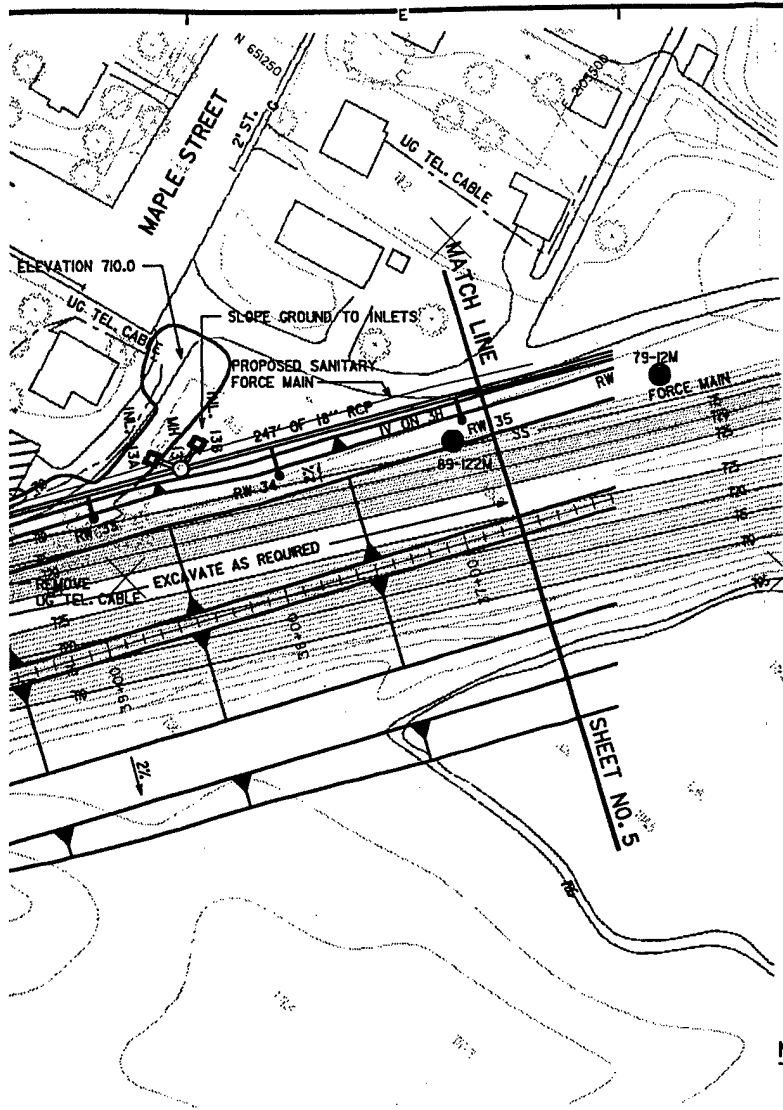
NOTES:

1. ELEVATIONS REFER TO M.S.L. (1929 ADJ.)
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.
3. GUARDRAIL IS TO BE INSTALLED FOR RAMP IN ACCORDANCE WITH THE UNIFORM FEDERAL ACCESSIBILITY STANDARDS (FED-STD-195)

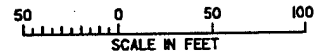
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DESIGNED: CHECKED: DRAWN: DESIGNED:	R.J.M. J.J.G. T.J. - R.J.M. W.J.M. - J.R.C.	CAD FILE NAME: MNIOP004.DGN		DRAWING NUMBER:	SHT 5
	CHECKED:	DATE: MARCH 1991		SPEC NO:	OF 31
	M34-CH-R-5/204				





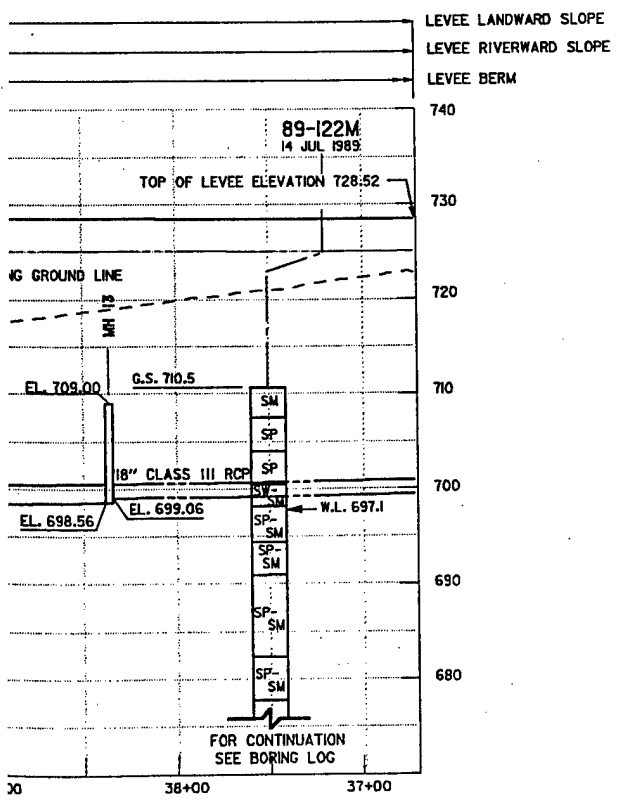


PLAN VIEW



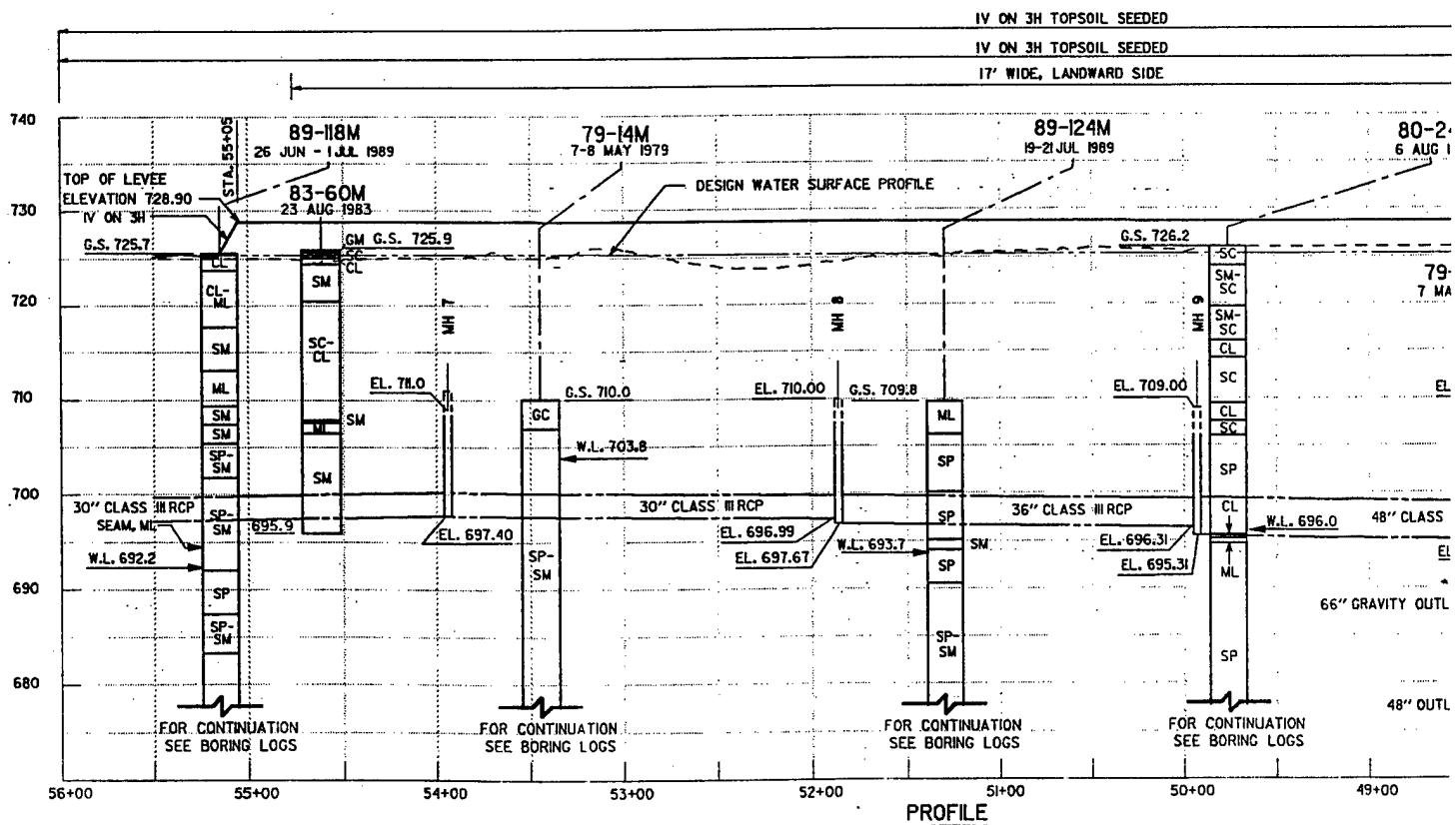
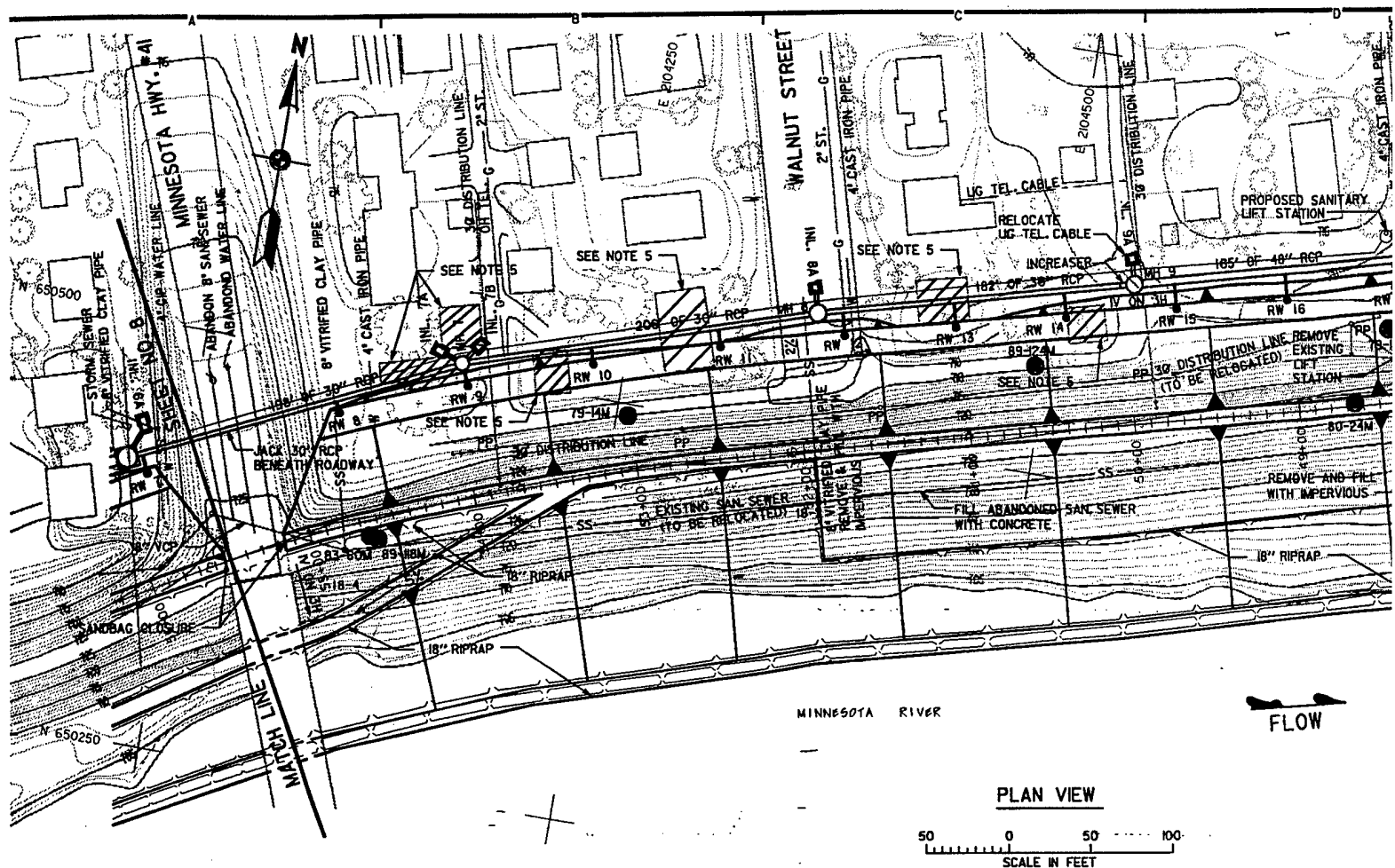
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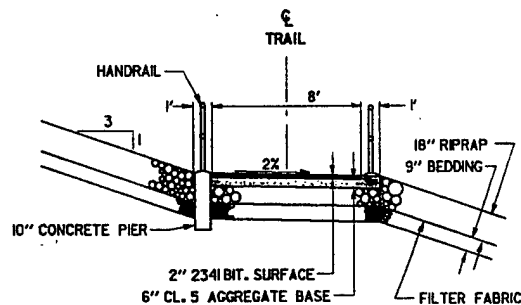
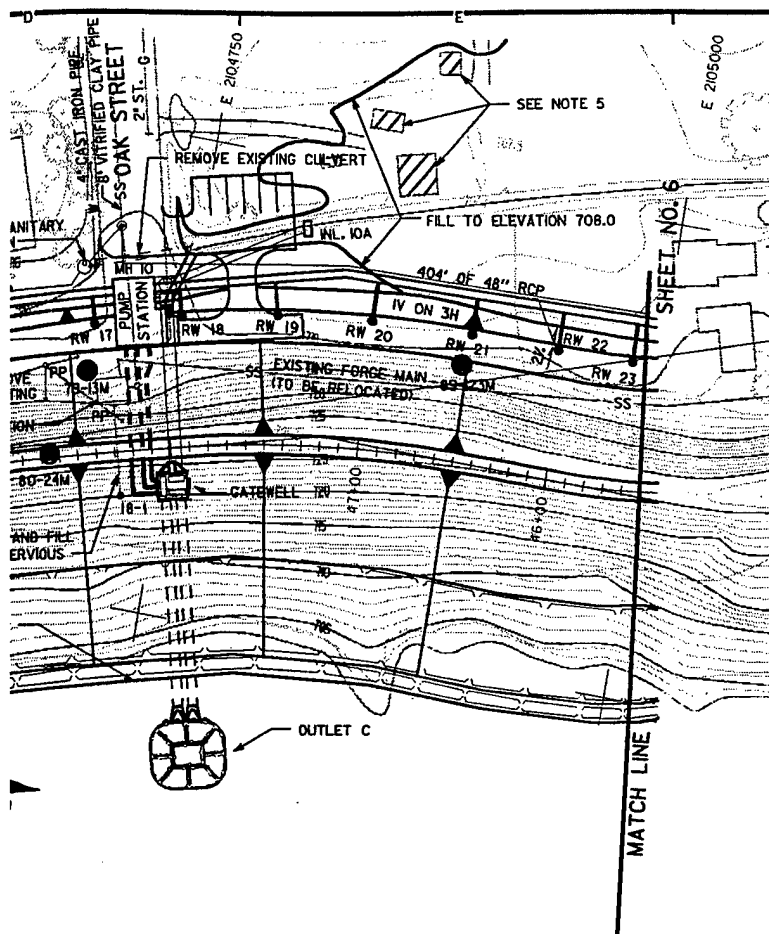
1. ELEVATIONS REFER TO M.S.L. (1929 ADJ.).
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.
3. FOR WELL SPACING & DEPTH SEE SHEET 20.
4. BUILDINGS TO BE REMOVED BY OTHERS, CONTRACTOR SHALL REMOVE SLAB AND FOUNDATION.



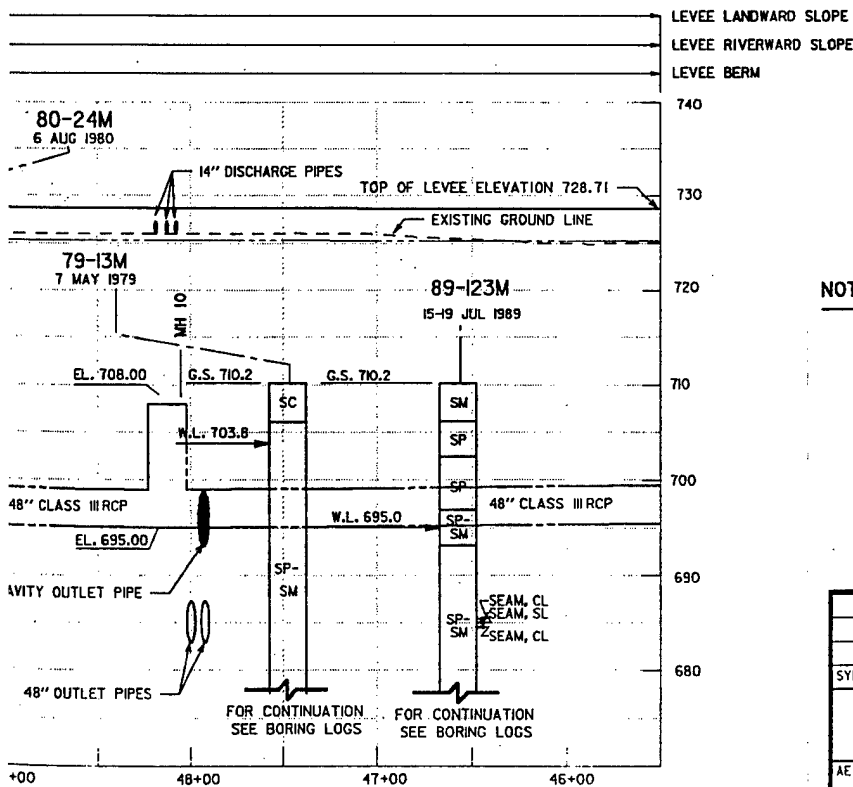
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AE APPROVING OFFICIAL:  		DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA			
DESIGNED: CHECKED: DRAWN: DESIGNED:	R.J.M. J.J.G. T.J. - R.J.M. W.J.M.-J.R.C.	CHASKA PROJECT		DRAINAGE & LEVEES PLAN & PROFILE STA. 36+70 TO 45+50	
	CHECKED: DATE: MARCH 1991	CAD FILE NAME: MNIPO05.DGN SPEC NO:		DRAWING NUMBER: <b>M34-CH-R-5/205</b>	
	SHT 6 OF 7				





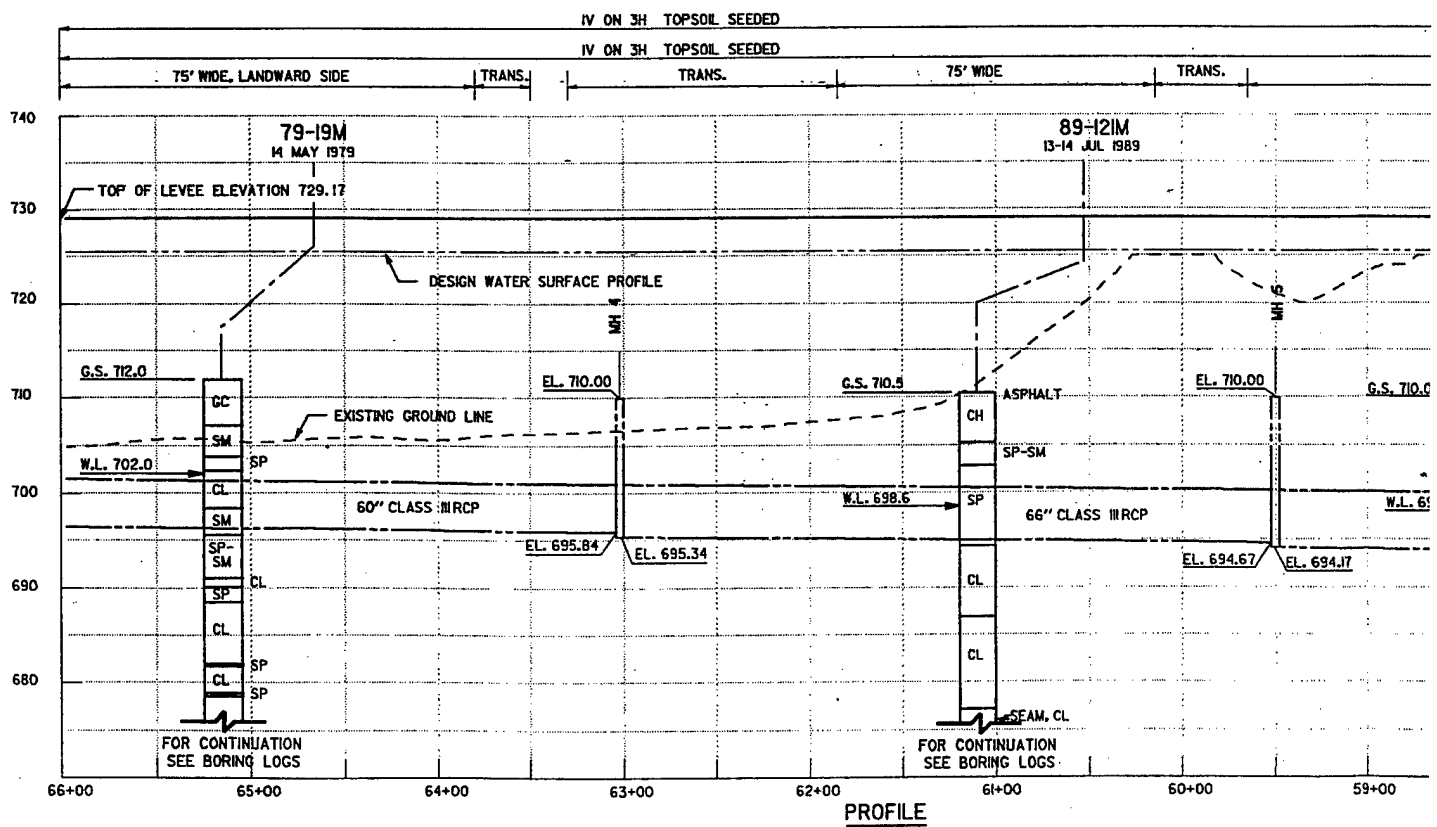
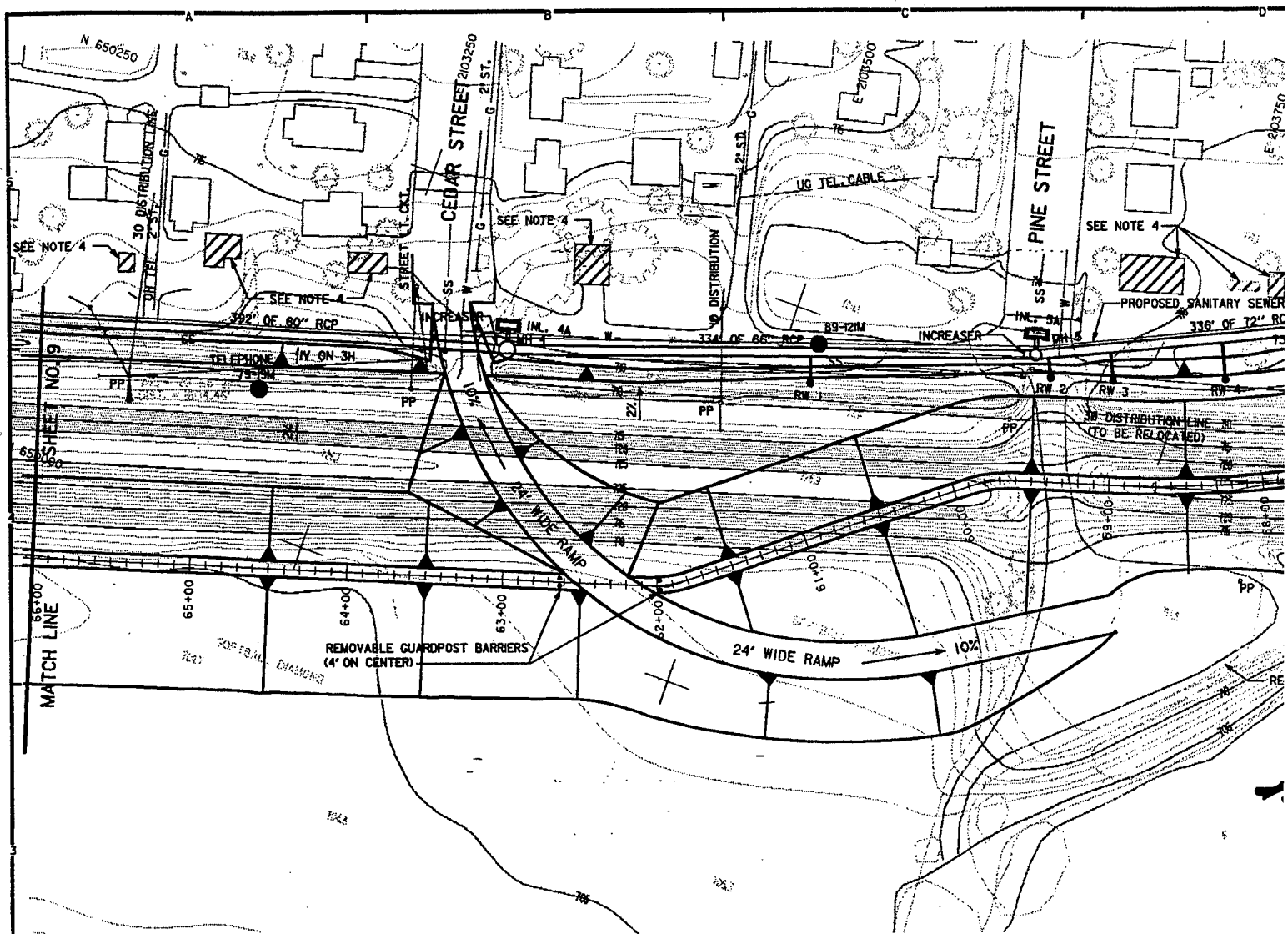
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TRAIL ON SIDE OF LEVEE  
NO SCALE

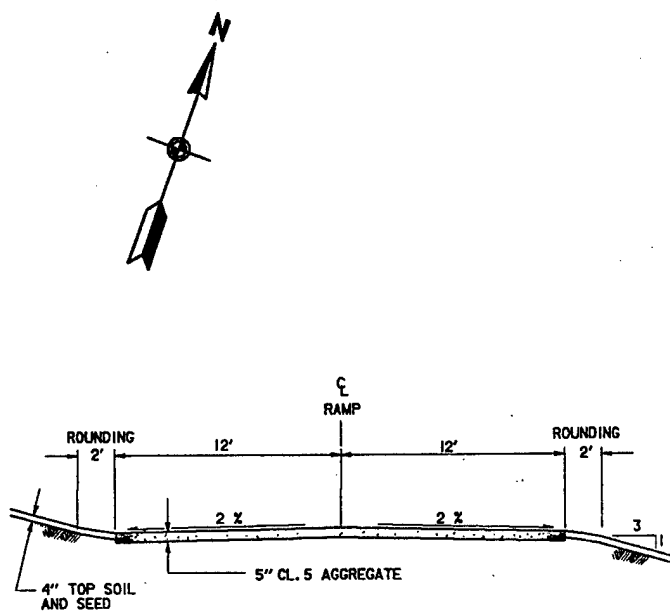
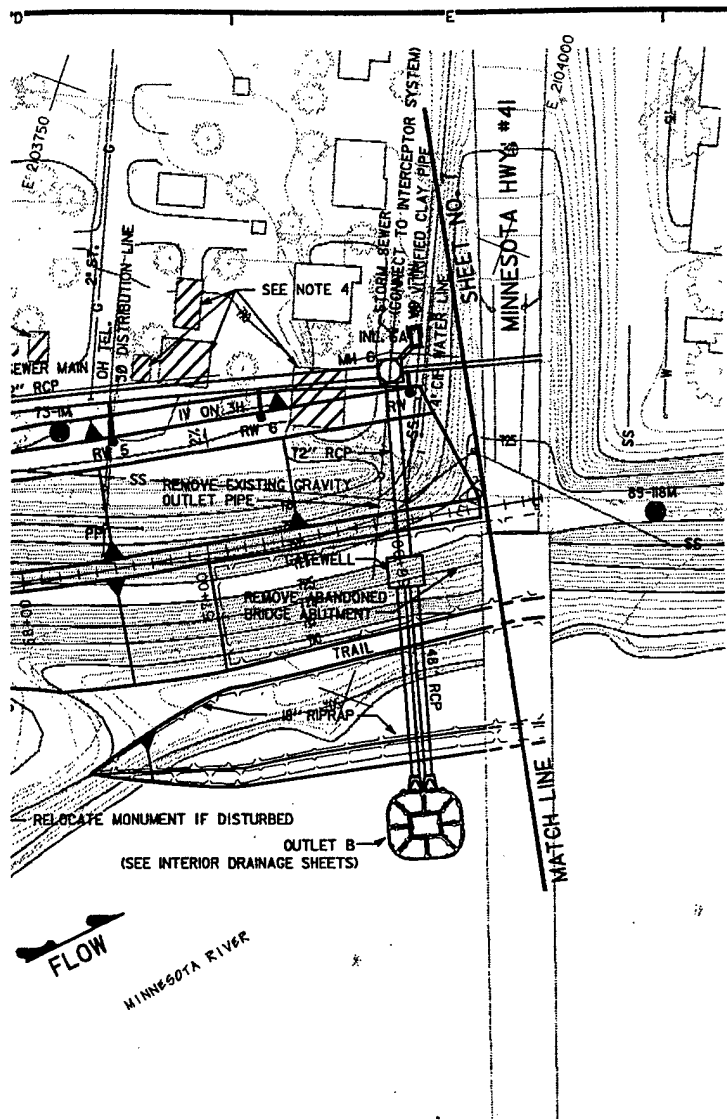


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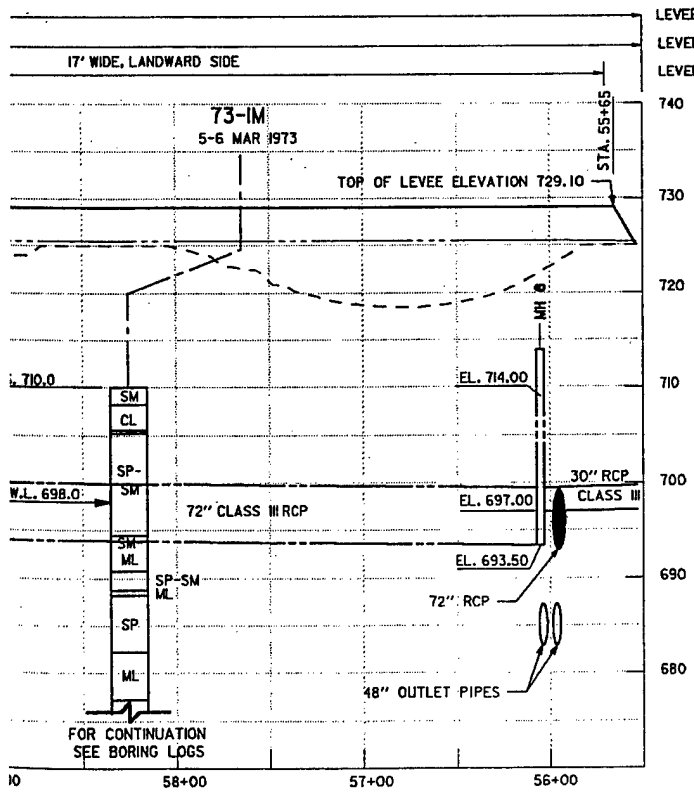
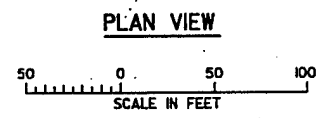
1. ELEVATIONS REFER TO M.S.L. (1929 ADJ.)
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.
3. ALL EXISTING UTILITIES BENEATH PROPOSED LEVEE SHALL BE RELOCATED.
4. SEE SITE PLAN SHEET FOR PUMPING STATION LAYOUT.
5. BUILDINGS TO BE REMOVED BY OTHERS, CONTRACTOR SHALL REMOVE SLAB AND FOUNDATION.
6. CONSTRUCT DRAINAGE SWALE INSIDE LEVEE BERM TO DIRECT RUNOFF INTO INTERCEPTOR PIPE INLETS.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, COMPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL: _____ _____		DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER <b>CHASKA PROJECT</b> CHASKA, MINNESOTA <b>DRAINAGE &amp; LEVEES</b> PLAN & PROFILE STA. 45+50 TO 55+50			
DESIGNED: R.J.M. CHECKED: J.J.G. DRAWN: T.J. - R.J.M. DESIGNED: W.J.M. - J.R.C.	CAD FILE NAME: MNIOP006.DGN DATE: MARCH 1991		DRAWING NUMBER: <b>M34-CH-R-5/206</b>		SHEET 7 OF 31





TYPICAL SECTION  
RAMP

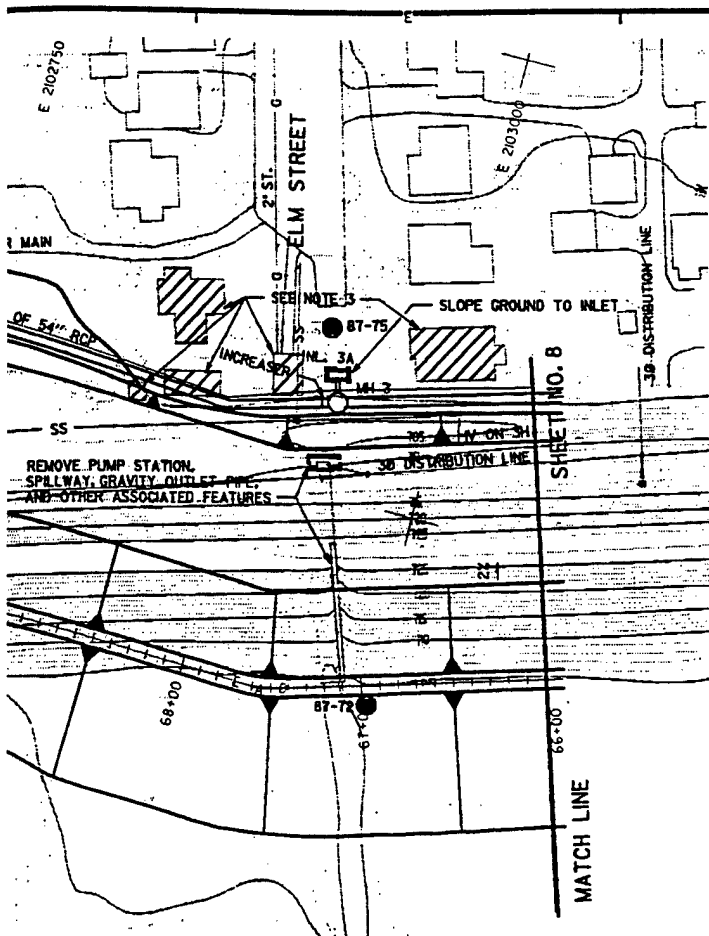


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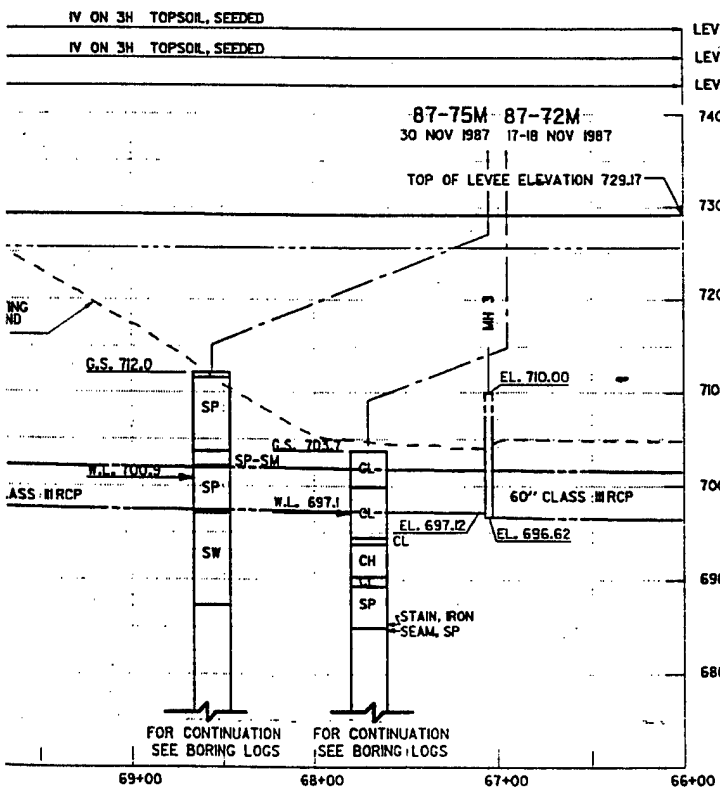
1. ELEVATIONS REFER TO M.S.L. 0929 ADJ.
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.
3. FOR WELL SPACING AND DEPTH SEE SHEET 20.
4. BUILDINGS TO BE REMOVED BY OTHERS, SLAB AND FOUNDATION REMOVED BY CONTRACTOR.
5. CONSTRUCT DRAINAGE SWALE ALONG INSIDE OF LEVEE BERM TO DIRECT RUNOFF INTO INTERCEPTOR PIPE INLETS.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA DRAINAGE &amp; LEVEES PLAN &amp; PROFILE STA. 55+50 TO 66+00</p>			
<p>DESIGNED: CHECKED: DRAWN: DESIGNED: CHECKED: DATE:</p>	<p>R.J.M. J.J.G. T.J. - R.J.M. W.J.M. - J.R.C.</p>	<p>CAD FILE NAME: MN0007.DGN</p>		<p>DRAWING NUMBER: MN34-CH-R-5/207</p>	<p>SHT 8 OF 31</p>
	<p>DATE: MARCH 1991</p>				
	<p>SPEC NO:</p>				
	<p>DATE: MARCH 1991</p>				





PLAN VIEW

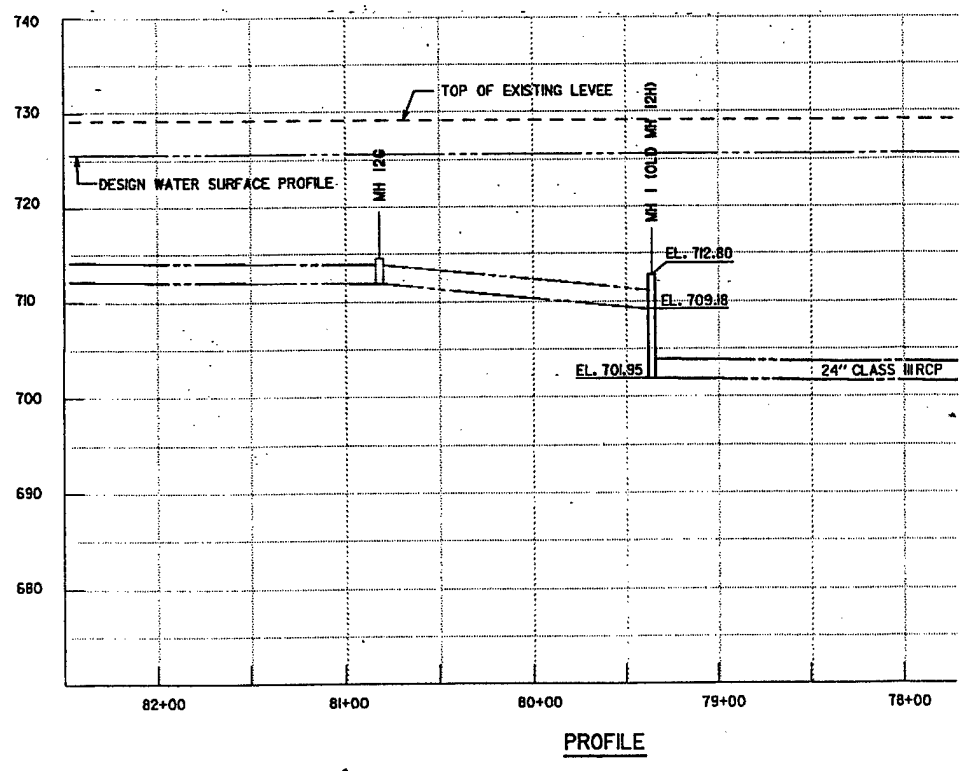
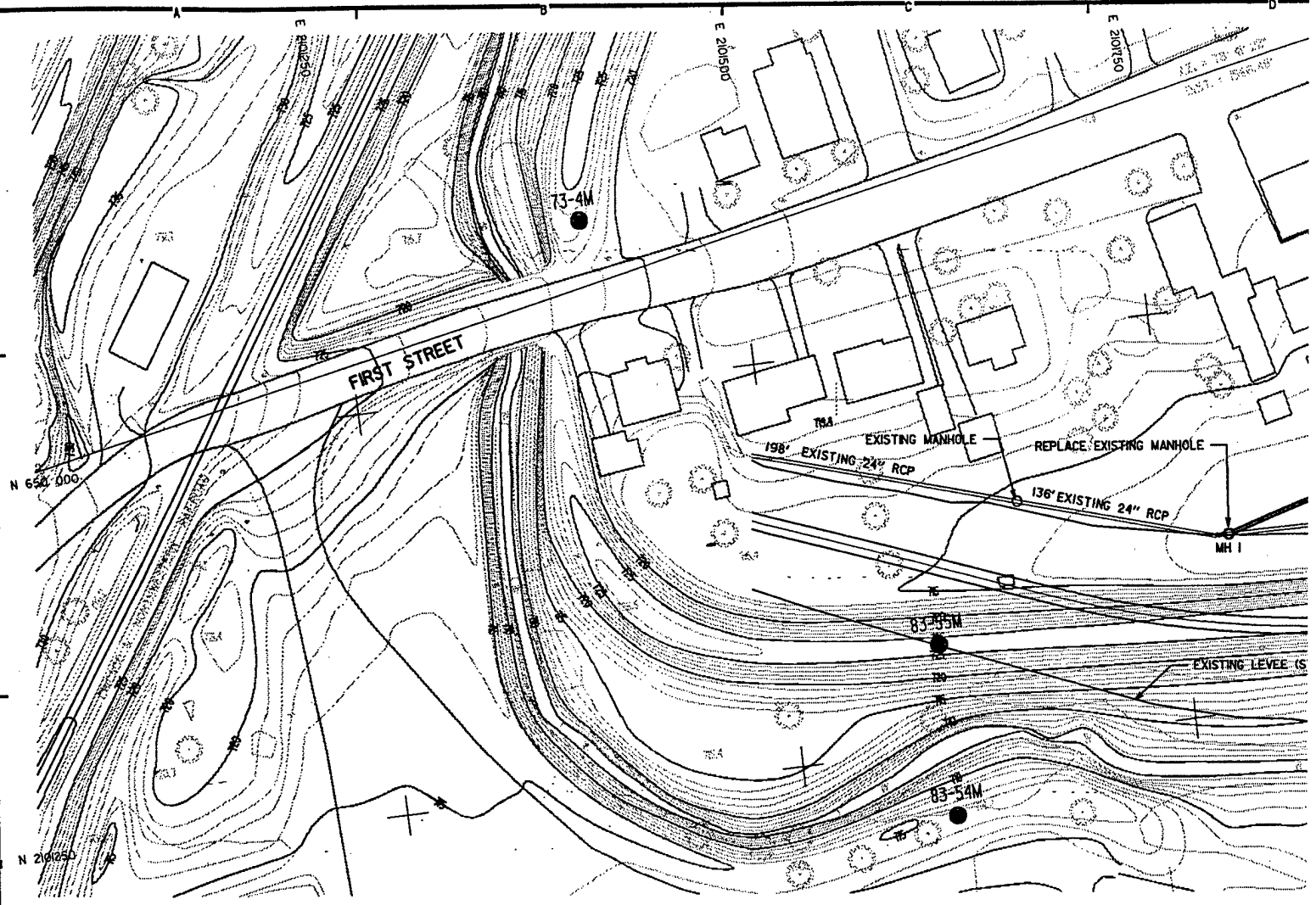


LEVEE LANDWARD SLOPE  
LEVEE RIVERWARD SLOPE  
LEVEE BERM

NOTES:

1. ELEVATIONS REFER TO M.S.L. (1929 ADJ.)
2. COORDINATES AND GRID FOR PROJECT ARE LAMBERT GRID, MINNESOTA SOUTH ZONE.
3. BUILDINGS TO BE REMOVED BY OTHERS. CONTRACTOR SHALL REMOVE SLAB AND FOUNDATION.

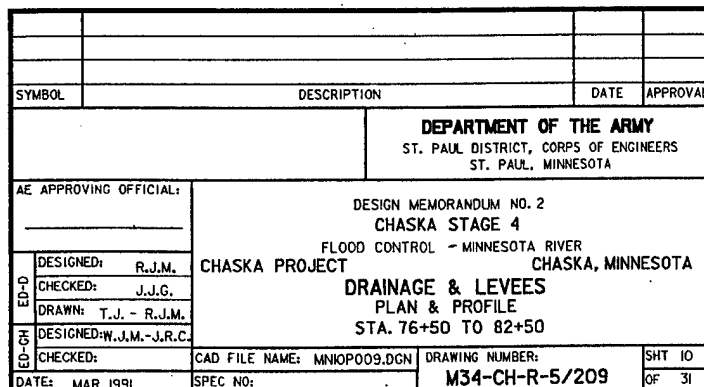
SYMBOL	DESCRIPTION	DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA</p>	
<p>ED-D DESIGNED: R.J.M. CHECKED: J.J.G. DRAWN: T.J.J. - R.J.M. DESIGNED: W.J.M. - J.R.C.</p>		<p><b>DRAINAGE &amp; LEVEES</b> PLAN &amp; PROFILE STA. 66+00 TO 76+50</p>	
<p>DATE: MARCH 1991</p>		<p>CAD FILE NAME: MNIOP008.DGN</p>	<p>DRAWING NUMBER: <b>M34-CH-R-5/208</b></p>
<p>SPEC NO:</p>		<p>SHT 9</p>	<p>CF 31</p>

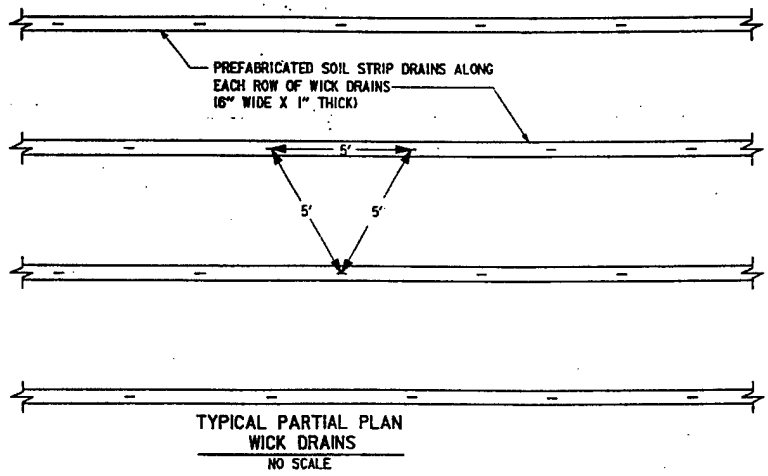
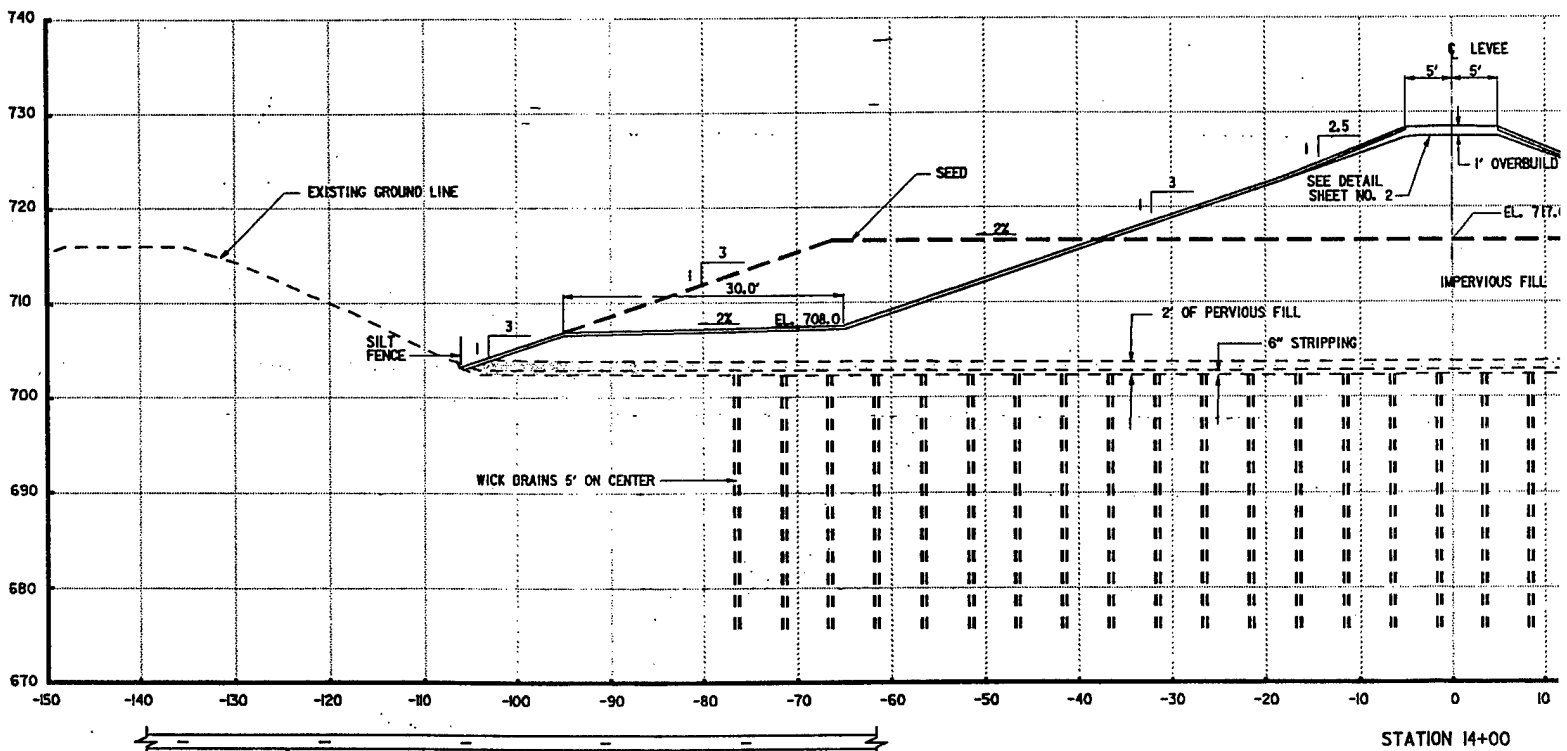
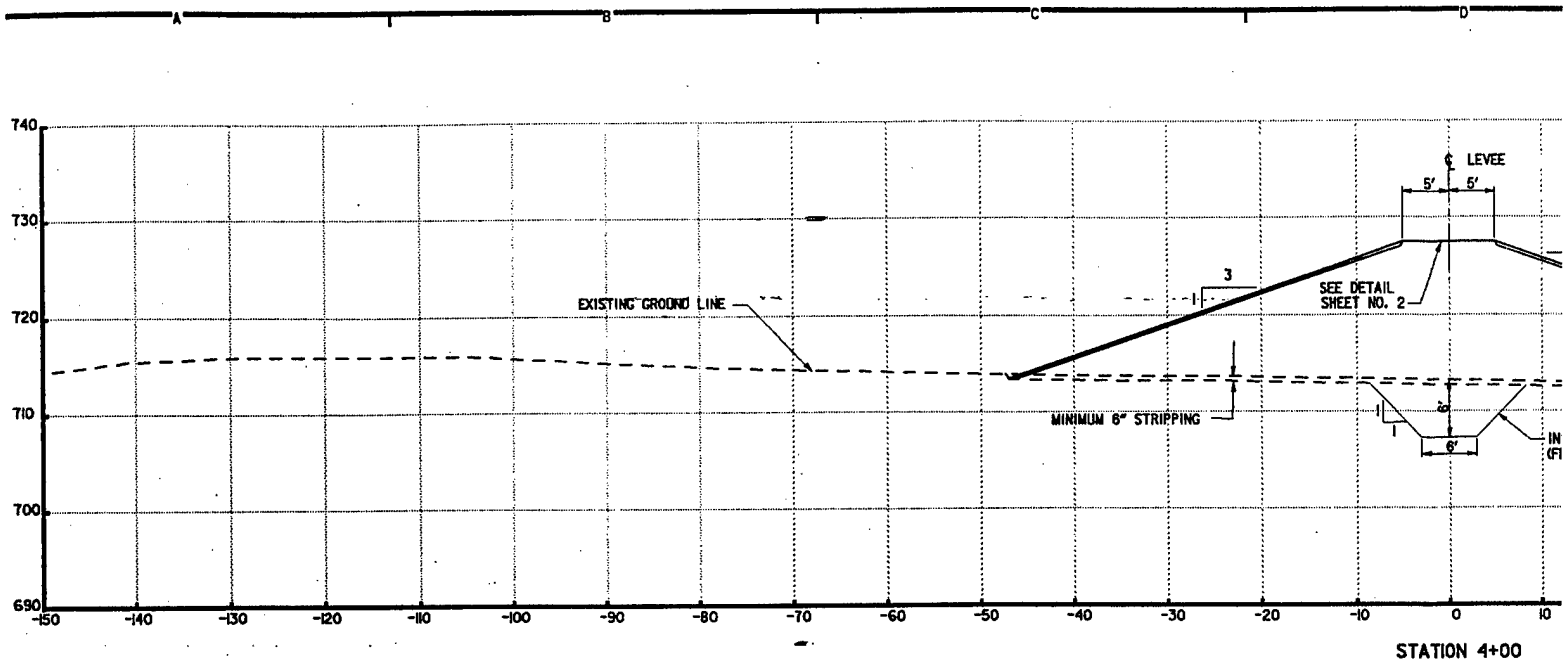


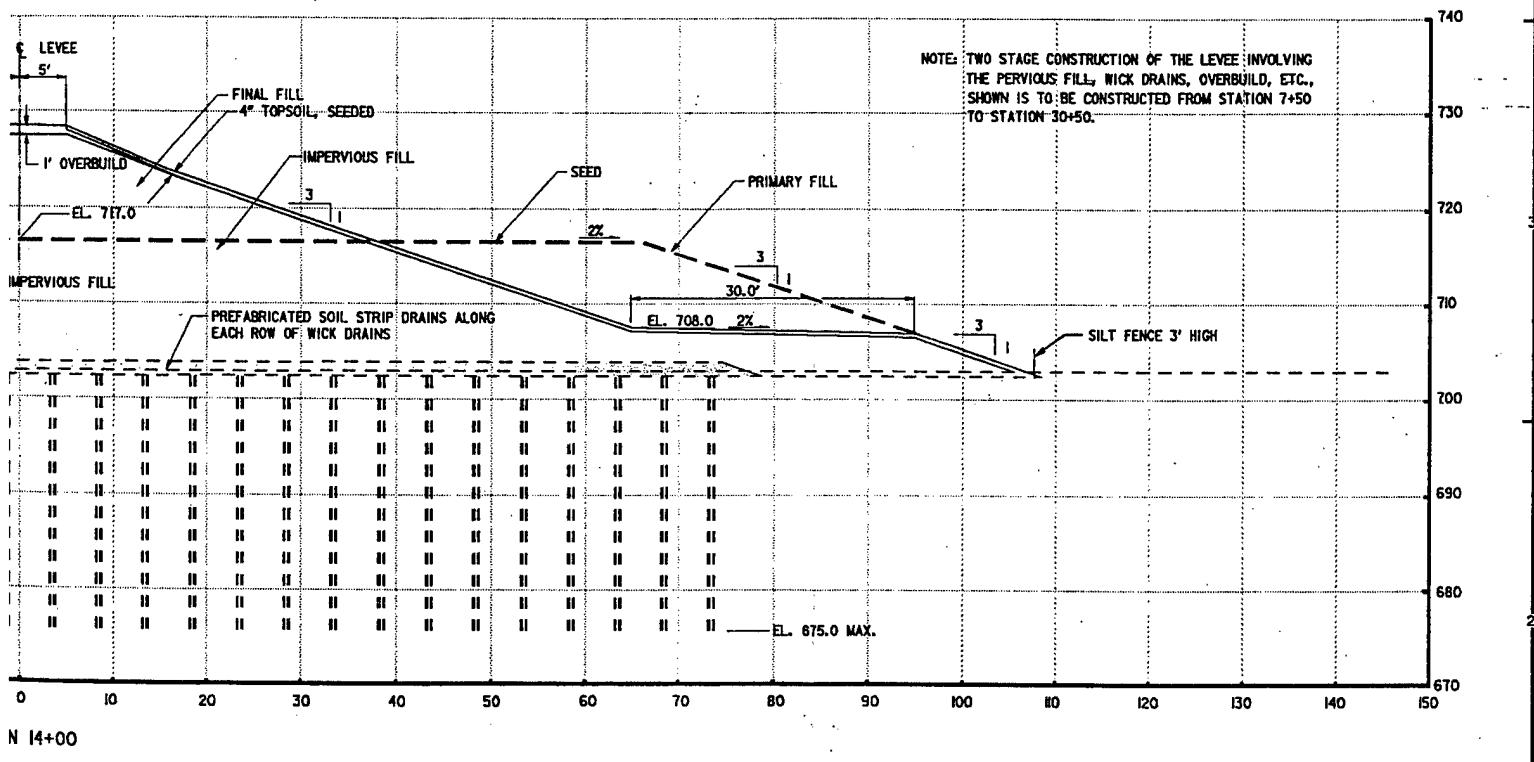
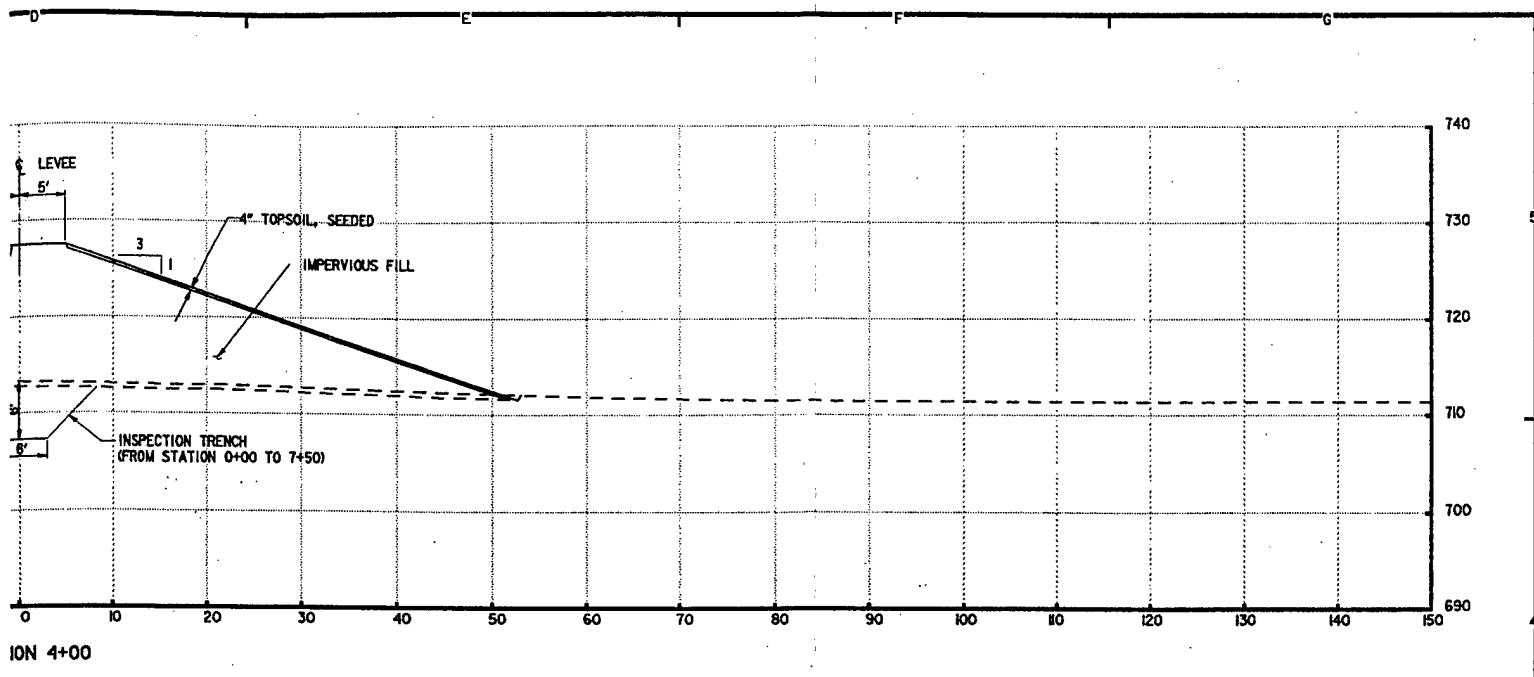




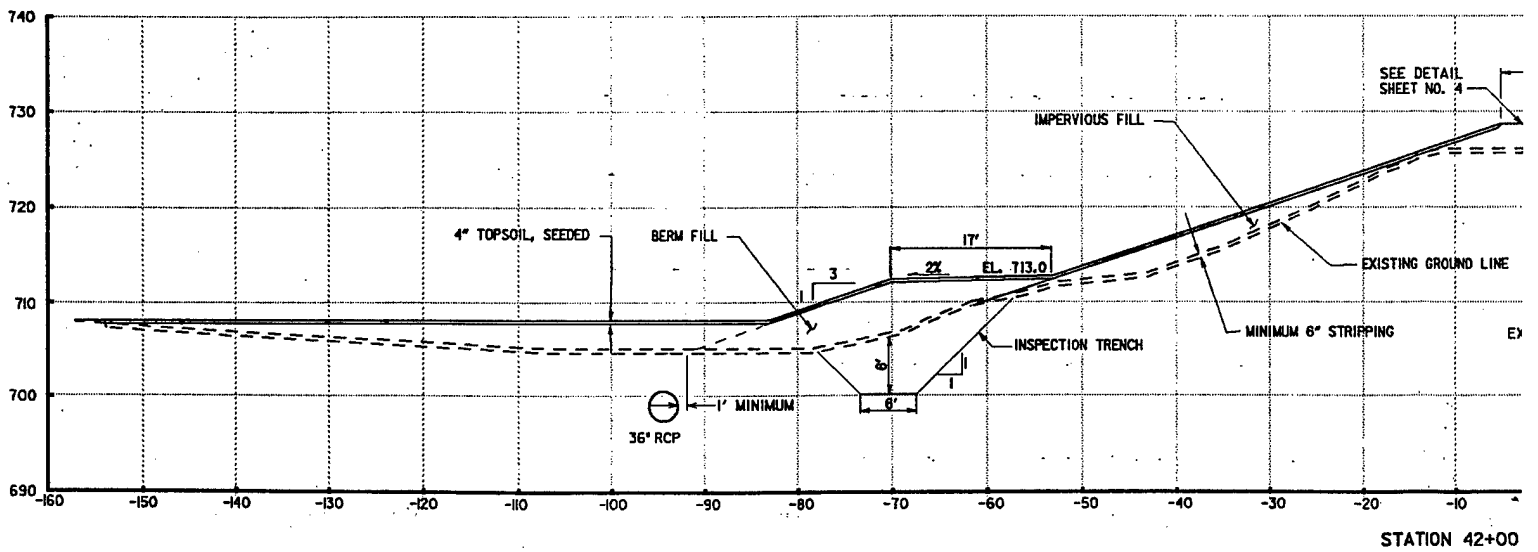
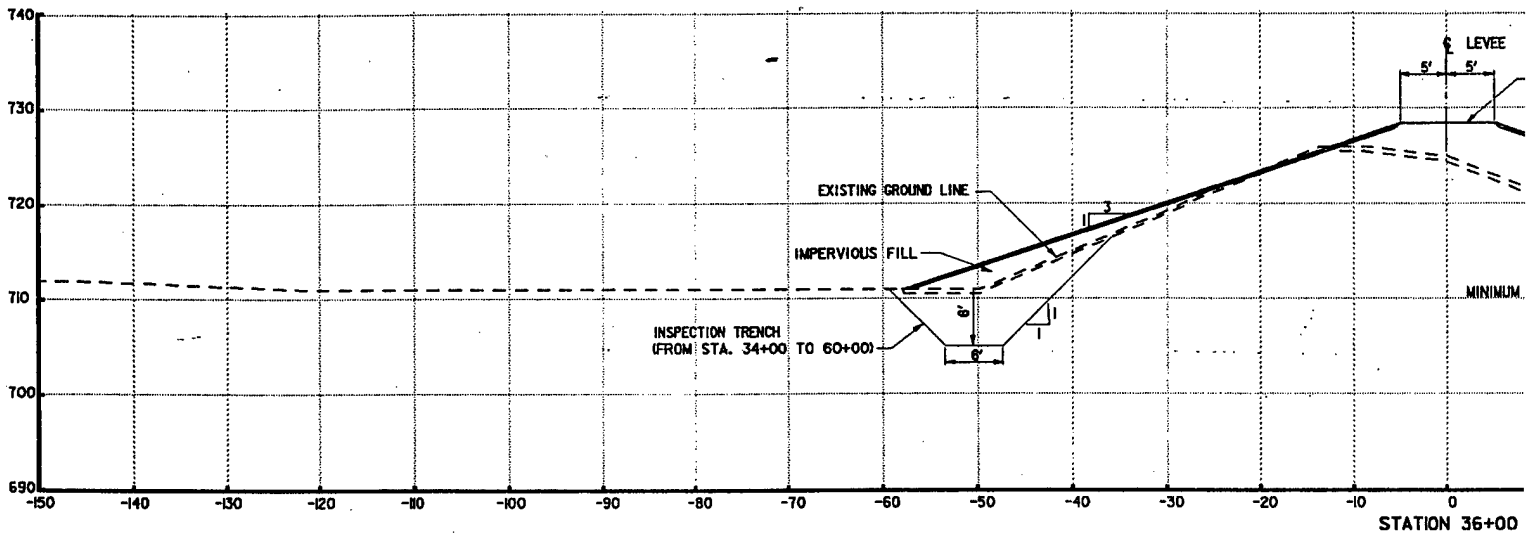
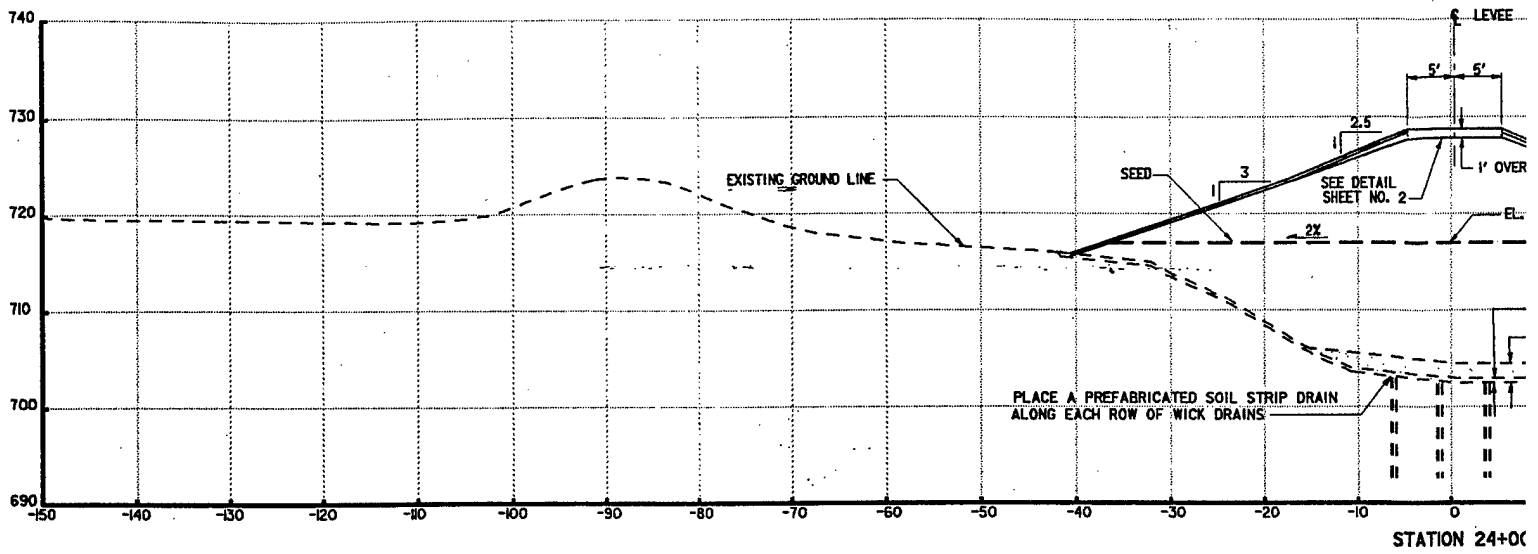
A horizontal scale bar labeled "SCALE IN FEET". It has major tick marks at 50, 0, 50, and 100. There are also minor tick marks between the major ones, indicating increments of 10 feet.

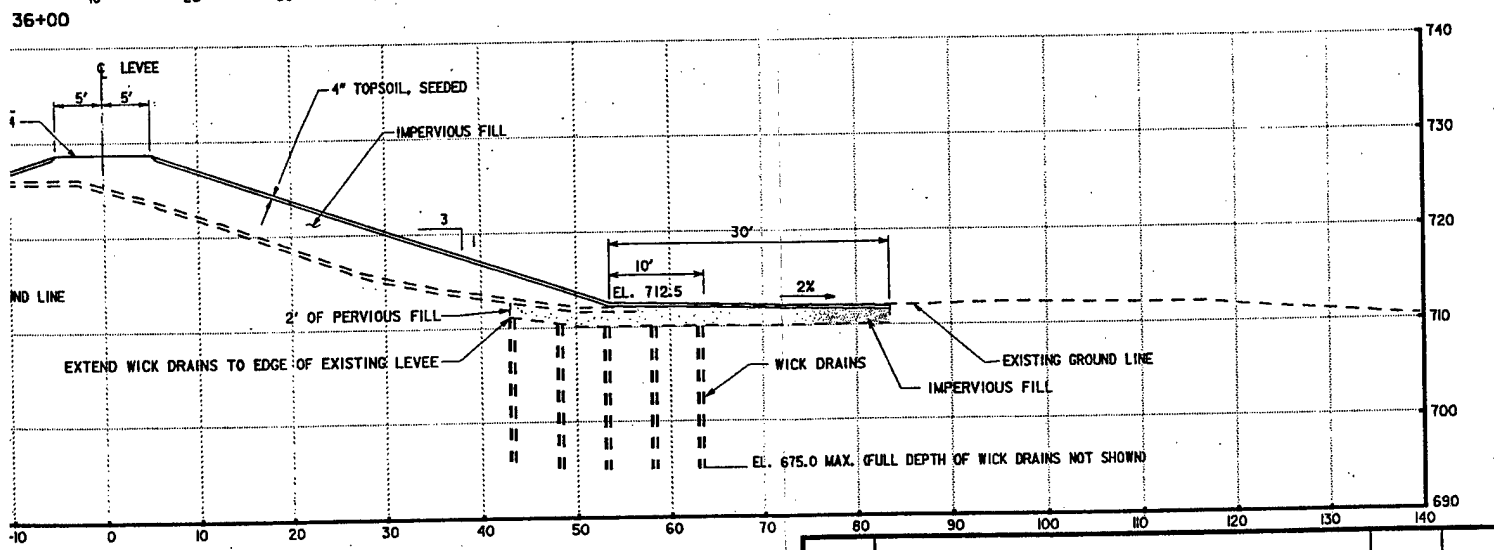
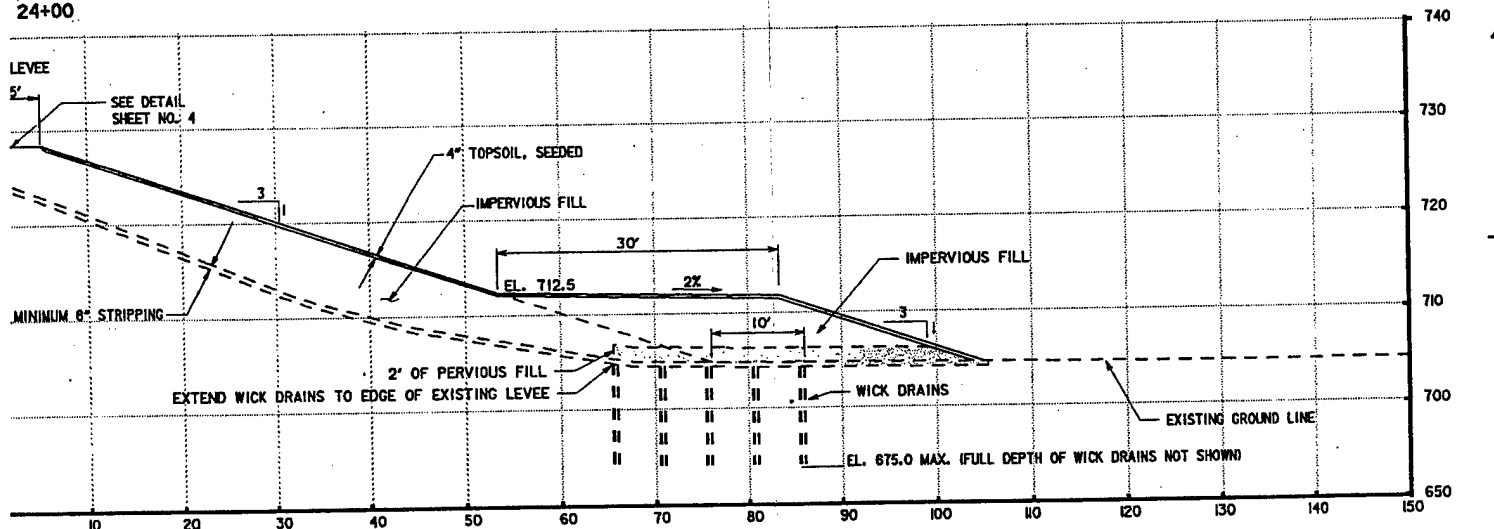
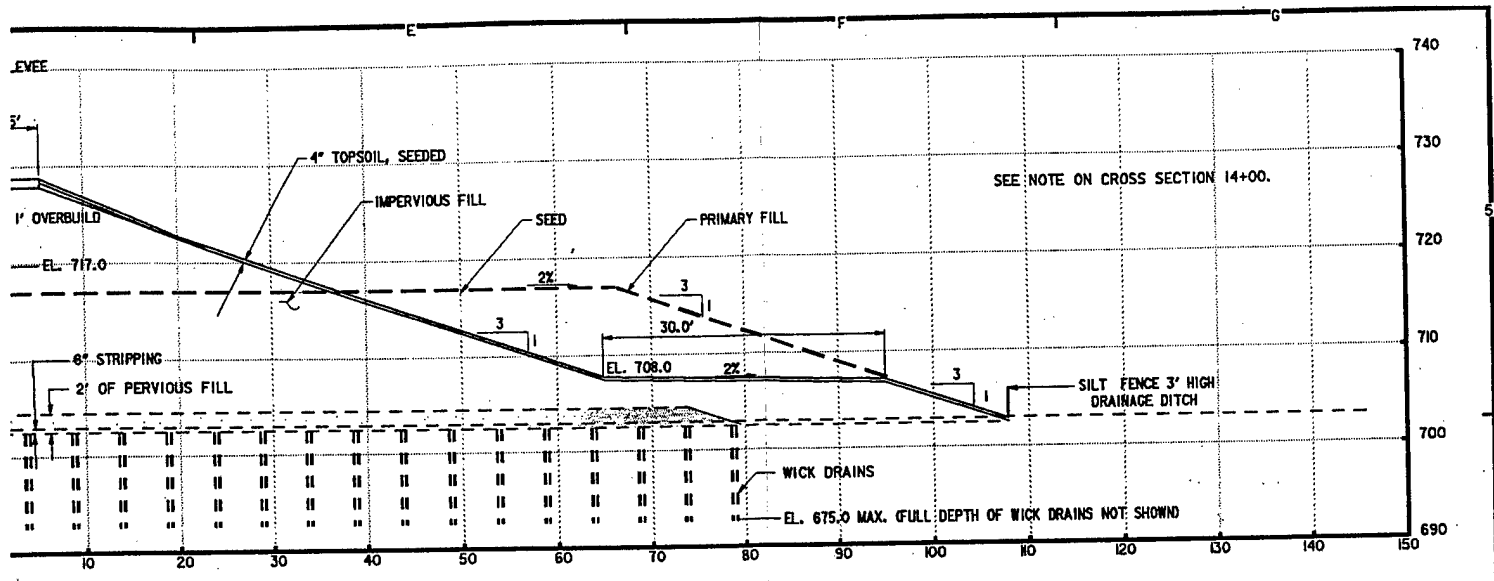






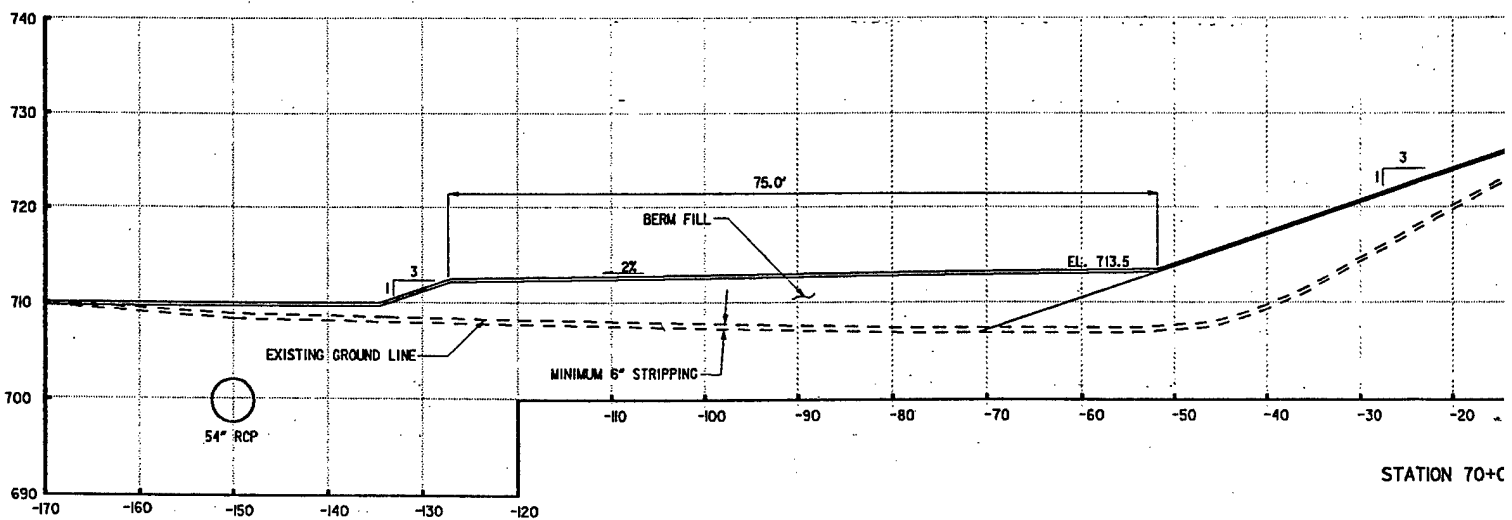
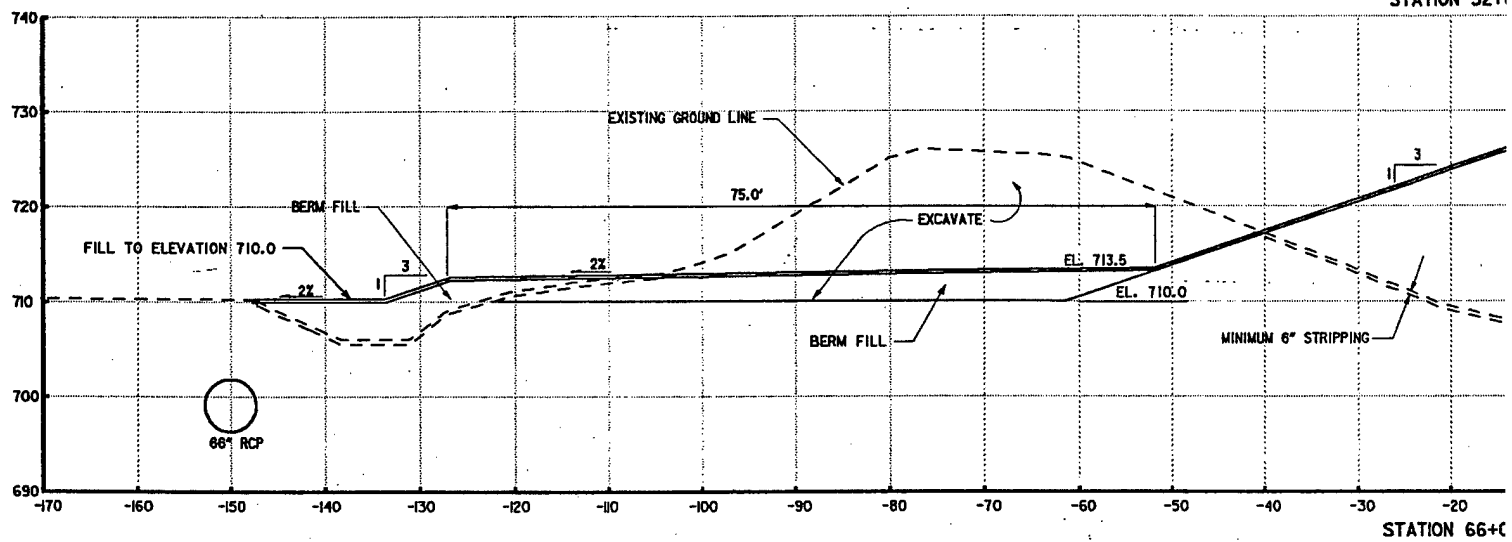
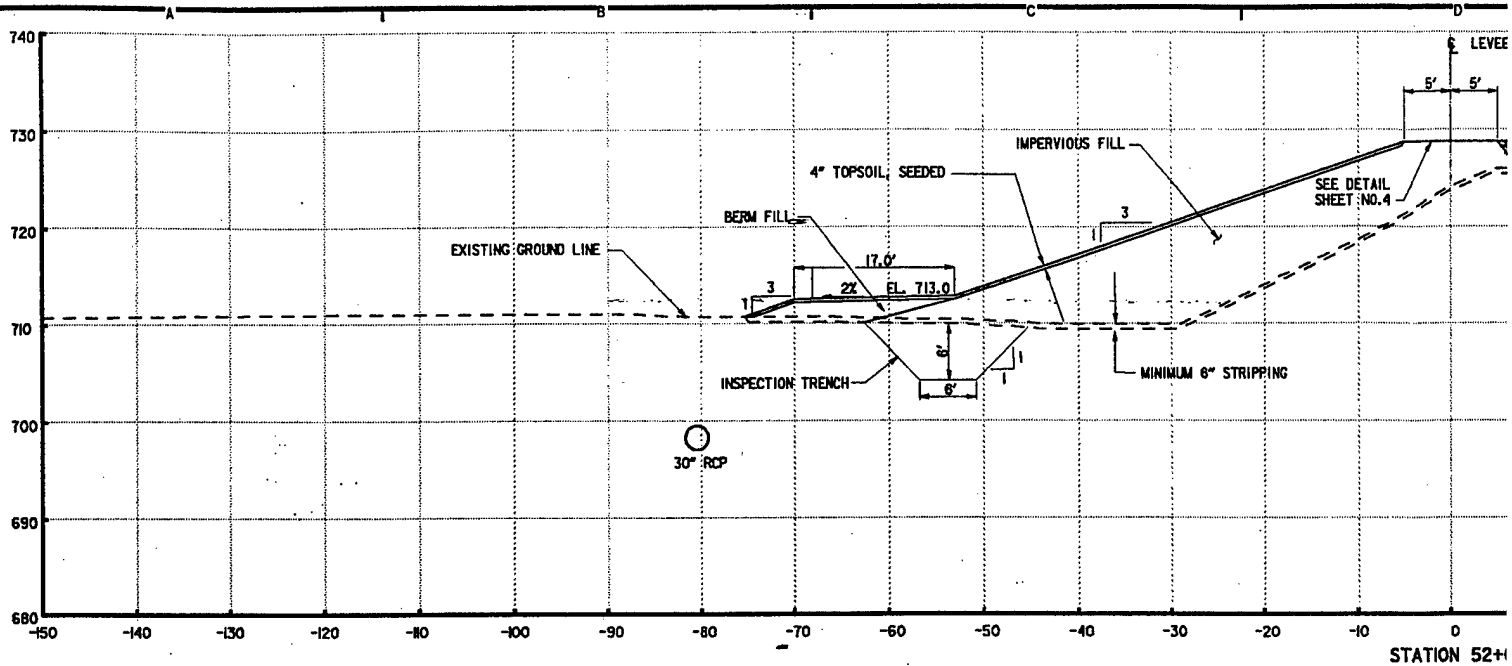
SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p>DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA</p>			
DESIGNED:	R.J.M.	<p>DRAINAGE AND LEVEES LEVEE CROSS SECTIONS STA. 4+00, 14+00, &amp; 24+00</p>			
	CHECKED: J.J.G.				
	DRAWN: T.J.				
	DESIGNED: J.R.C.				
CHECKED:		CAD FILE NAME: MNIOPXSL.DGN	DRAWING NUMBER:	SHT #	
DATE: MARCH 1991		SPEC NO:	M34-CH-R-5/210	OF 31	

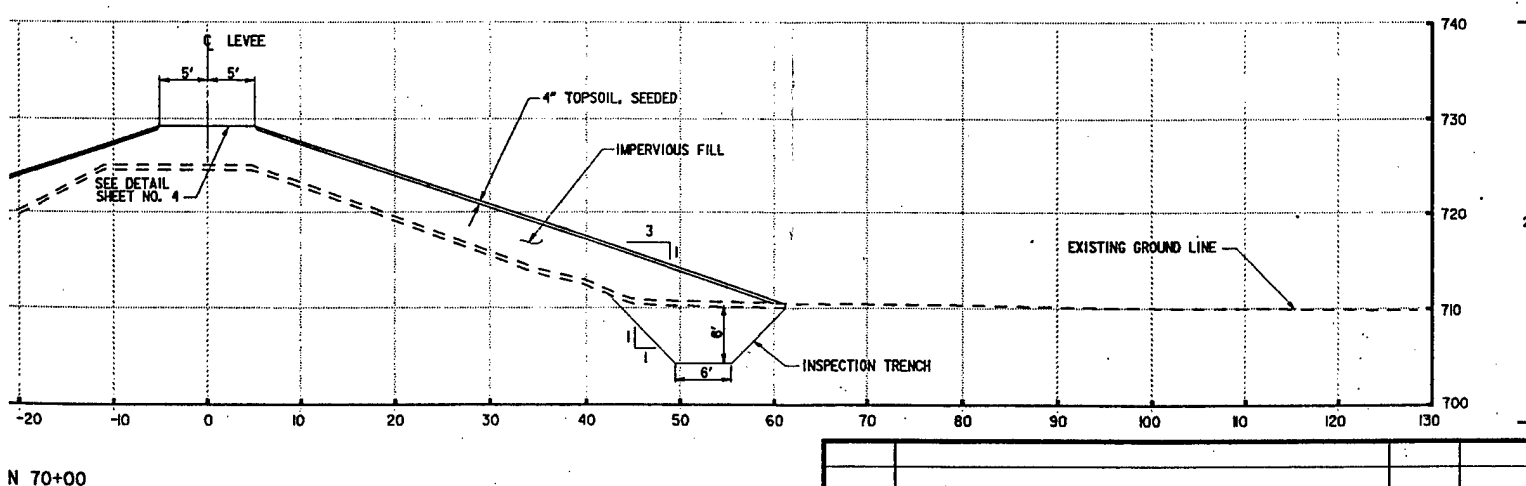
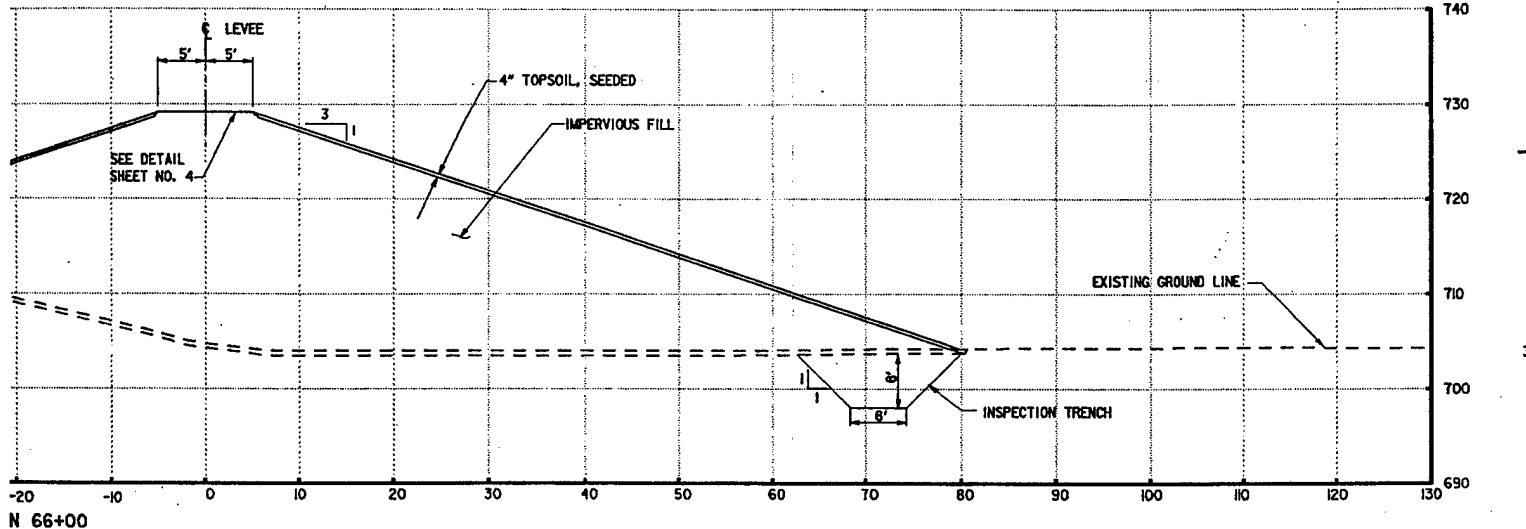
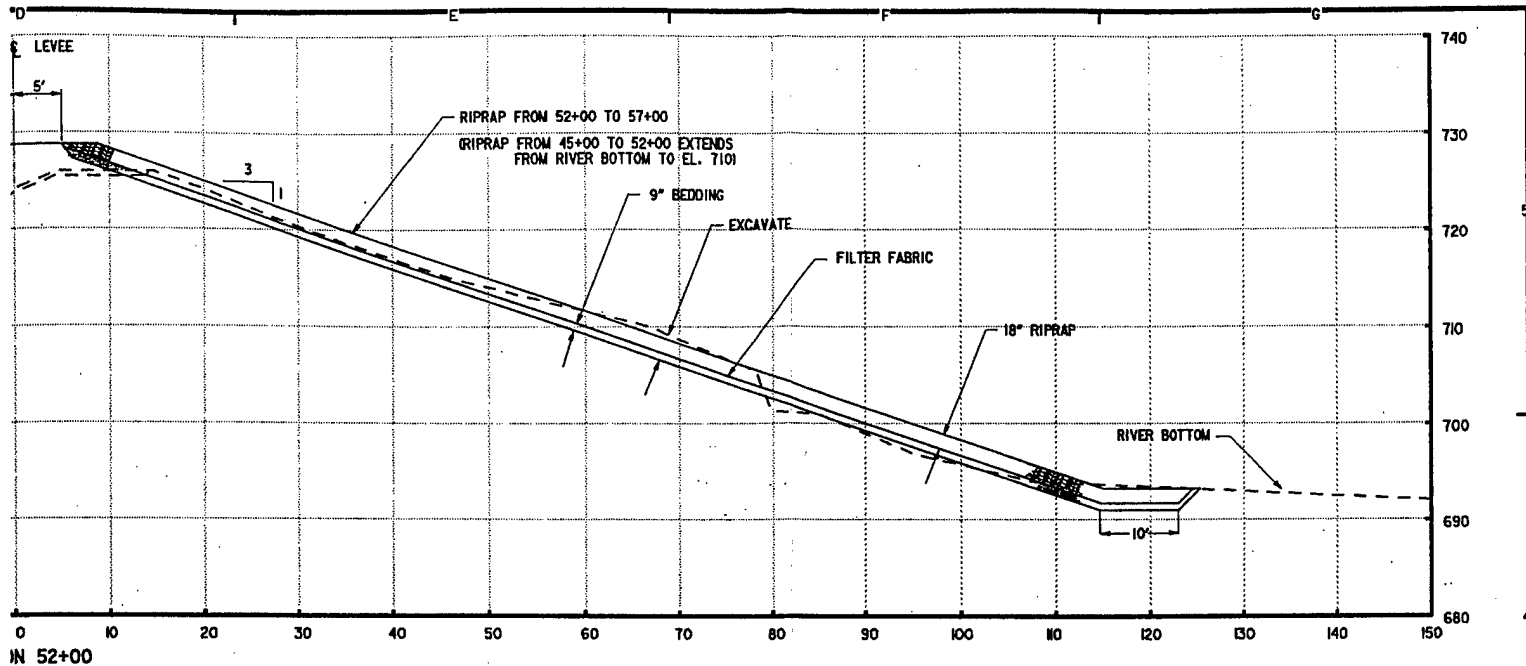




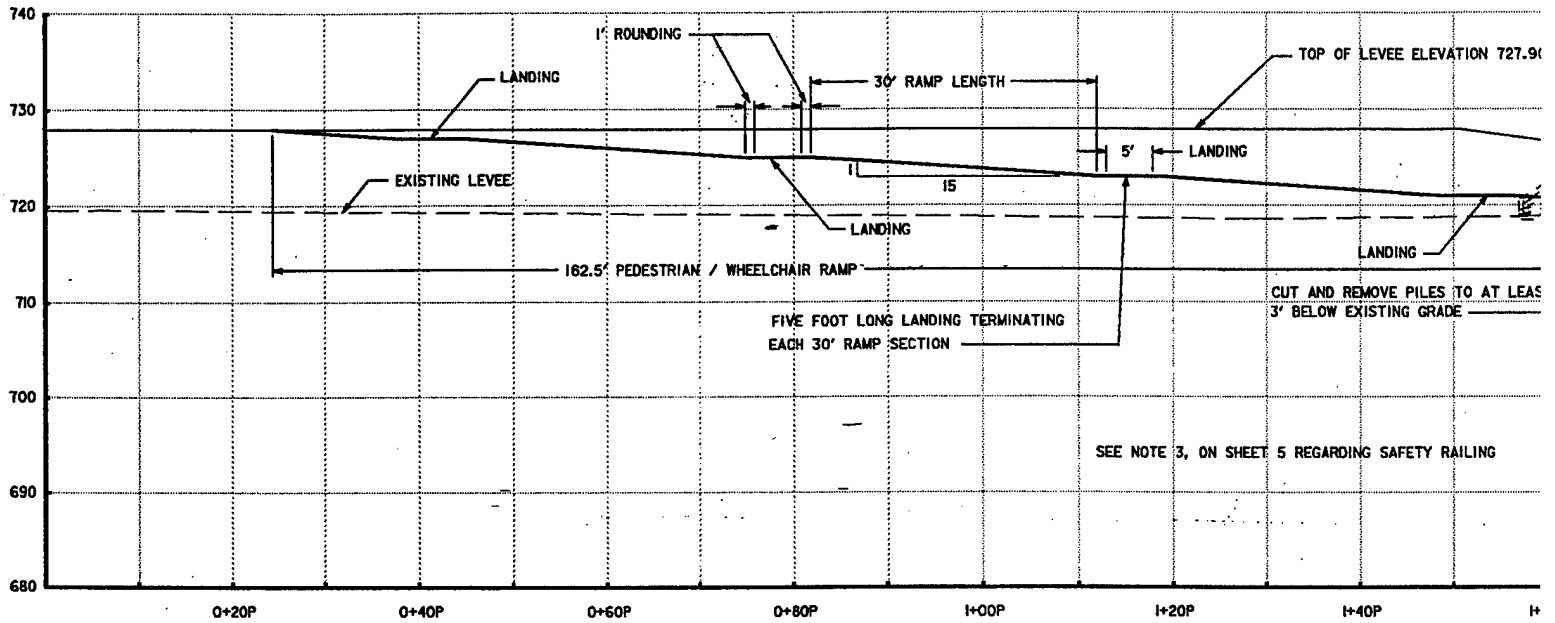
1 42+00

SYMBOL	DESCRIPTION	DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA</p>	
<p>DESIGNED: R.J.M. CHECKED: J.J.G. DRAWN: T.J.</p>		<p>CHASKA PROJECT DRAINAGE AND LEVEES LEVEE CROSS SECTIONS STA. 24+00, 36+00, AND 42+00</p>	
<p>DESIGNED: J.R.C. CHECKED:</p>		<p>CAD FILE NAME: MNIOPXS2.DGN</p>	<p>DRAWING NUMBER: M34-CH-R-5/2II</p>
<p>DATE: MARCH 1991</p>		<p>SPEC NO:</p>	<p>SHT 12 OF 31</p>





SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA <b>DRAINAGE AND LEVEES</b> LEVEE CROSS SECTIONS STA. 52+00, 66+00, AND 70+00</p>			
ED-D	DESIGNED: R.J.M.	CAD FILE NAME: MNIOPXS3.DGN		DRAWING NUMBER:	SHT 13
	CHECKED: J.J.G.				OF 31
	DRAWN: T.J.				
	DESIGNED: J.R.C.				
DATE: MARCH 1991		SPEC NO:		M34-CH-R-5/212	

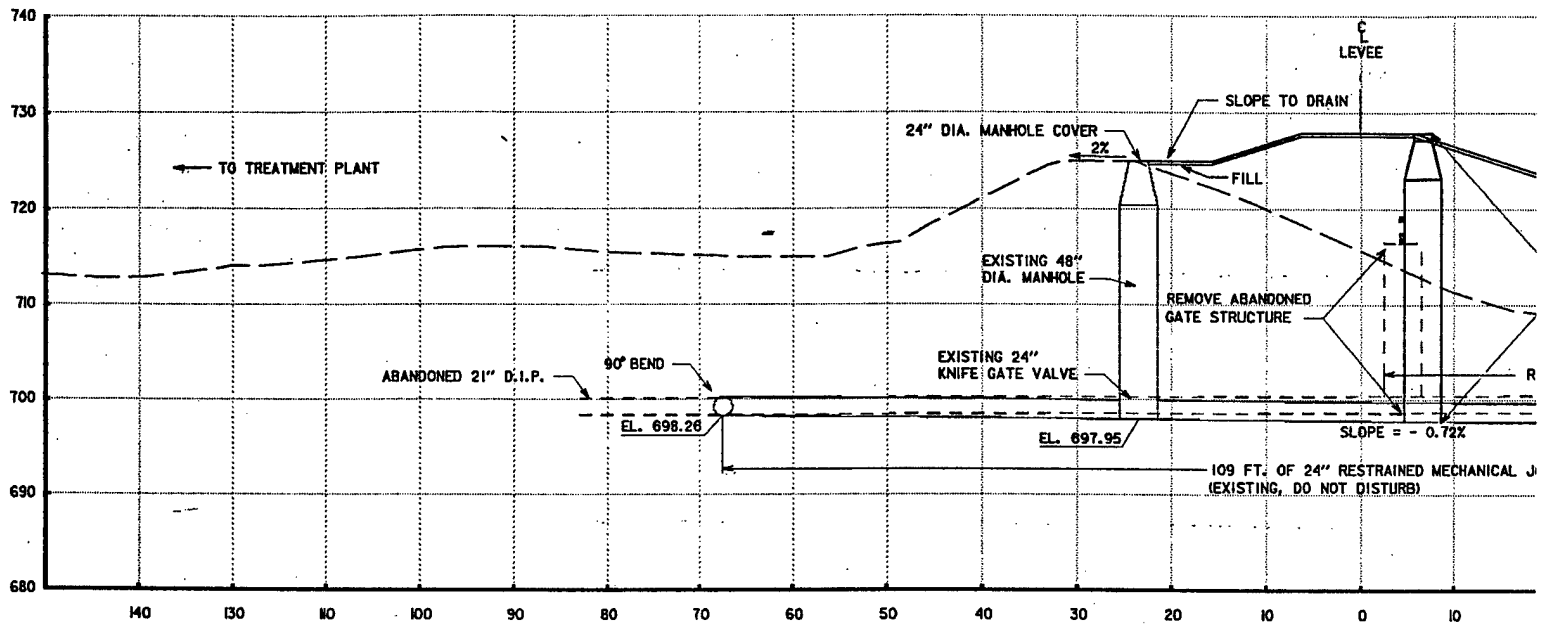


**PROFILE**  
PEDESTRIAN / WHEELCHAIR RAMP

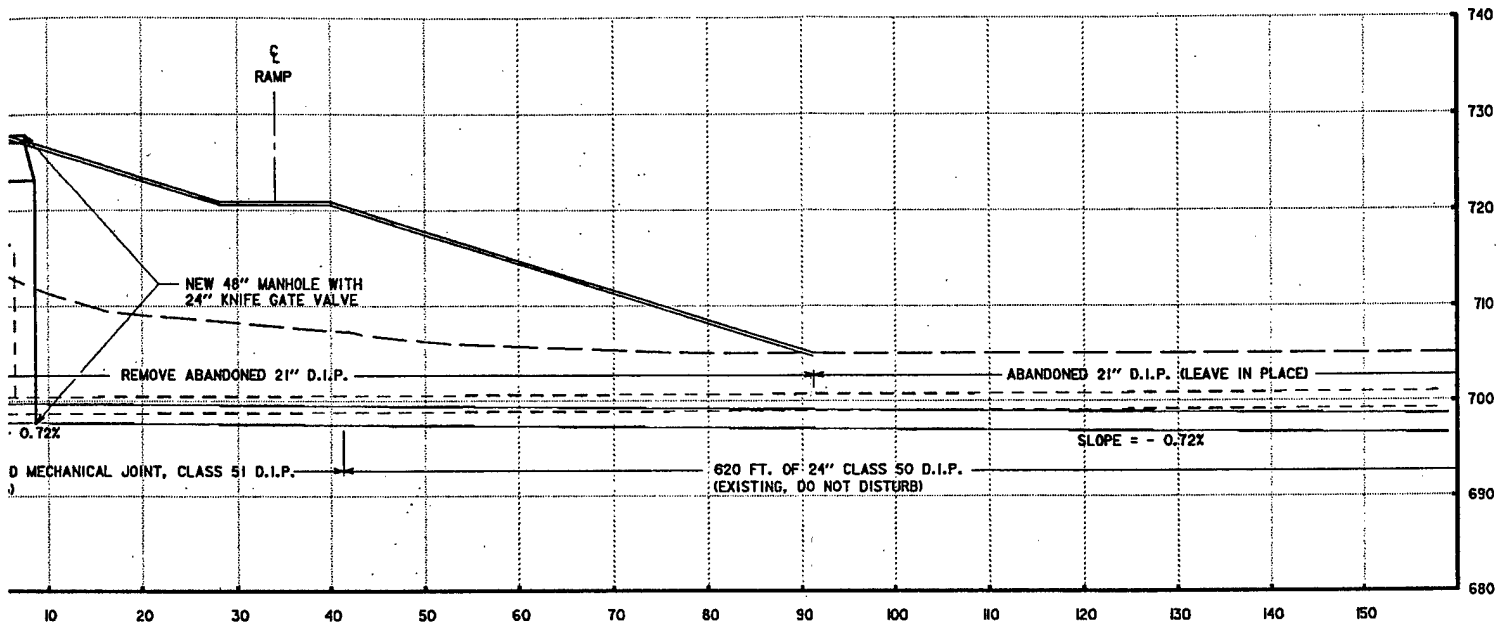




SYMBOL	DESCRIPTION			DATE	APPROVAL
AE APPROVING OFFICIAL:			<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>		
DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER <b>CHASKA PROJECT</b>					
PROFILE PEDESTRIAN BRIDGE APPROACH					
CAD FILE NAME: MNIOPATH.DGN			DRAWING NUMBER:		SHT 14
DATE: 05-22-90			SPEC NO:		MN34-CH-R-5/212
					OF 31



**PROFILE**  
TREATMENT PLANT OUTFALL PIPE  
(LEVEE INTERSECTION AT STA. 32+00)

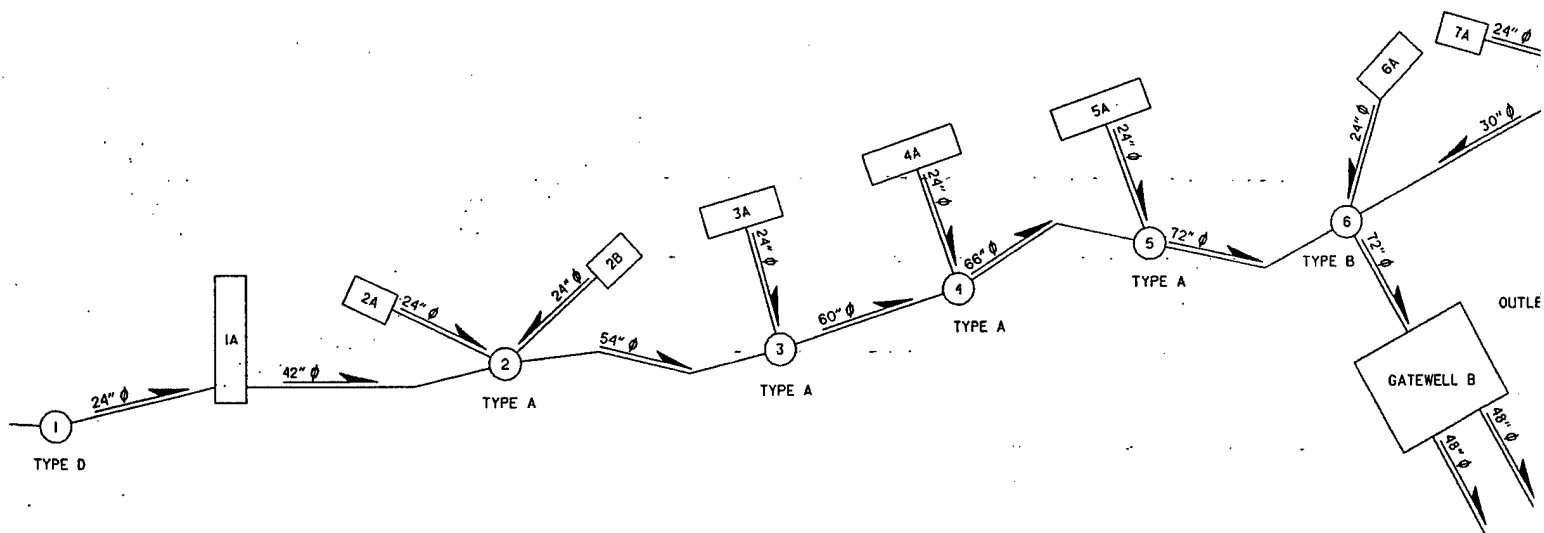


FALL PIPE  
 AT STA. 32+00

SYMBOL		DESCRIPTION		DATE	APPROVAL	
<b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA						
AE APPROVING OFFICIAL:		DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA				
DESIGNED:	R.J.M.	<b>PROFILE</b> TREATMENT PLANT OUTFALL PIPE				
	CHECKED:					J.J.G.
	DRAWN:					R.J.M.
DESIGNED:		CAD FILE NAME: MNIPOUTF.DGN		DRAWING NUMBER:	SHT 15	
CHECKED:		DATE: MARCH 1991		SPEC NO:	OF 31	
				M34-CH-R-5/214		

MANHOLE SCHEDULE																			
STRUCTURE NO.	TYPE	STATION	CASTING RIM ELEVATION	ELEVATION A	RISER DIA.	BARREL DIA.	SLAB DIA.	H	W	INTERCEPTOR				OUTLET PIPE C		INLET			
										PIPE A		PIPE B		PIPE C		PIPE D		PIPE E	
										INVERT	DIA.	INVERT	DIA.	INVERT	DIA.	INVERT	DIA.	INVERT	DIA.
MH-1	D	--	712.8	701.7	--	48"	85"	--	--	709.18	24"	701.95	24"	--	--	--	--	--	--
MH-2	A	71+15	710.0	697.91	48"	--	--	5'-6"	12'-0"	--	42"	--	54"	--	--	705.73	24"	705.73	24"
MH-3	A	67+05	710.0	696.62	48"	--	--	4'-3"	10'-6"	--	54"	--	60"	--	--	705.73	24"	--	--
MH-4	A	63+03	710.0	695.34	48"	--	--	4'-8"	10'-8"	--	60"	--	66"	--	--	705.73	24"	--	--
MH-5	A	59+51	710.0	694.17	48"	--	--	--	--	--	66"	--	72"	--	--	705.73	24"	--	--
MH-6	B	55+88	714.0	692.92	48"	--	--	--	--	697.00	30"	693.50	72"	693.50	72"	709.73	24"	--	--
MH-7	C	53+94	711.0	697.11	48"	60"	92"	--	--	697.40	30"	697.40	30"	--	--	706.73	24"	706.73	24"
MH-8	C	51+85	710.0	696.34	48"	60"	120"	--	--	696.99	30"	696.67	36"	--	--	705.73	24"	--	--
MH-9	A	49+94	709.0	695.31	48"	--	--	3'-8"	10'-0"	--	36"	--	48"	--	--	704.73	24"	--	--
MH-10	B	47+95	710.3	693.50	72"	--	--	--	--	695.00	48"	694.82	48"	693.50	66"	702.51	36"	--	--
MH-11	A	43+75	708.0	695.62	48"	--	--	3'-8"	10'-0"	--	36"	--	48"	--	--	703.73	24"	--	--
MH-12	C	41+43	708.0	696.73	48"	60"	120"	--	--	698.06	24"	697.06	36"	--	--	703.73	24"	--	--
MH-13	D	38+36	709.0	698.31	--	48"	100"	--	--	699.06	18"	698.56	24"	--	--	704.73	24"	704.73	24"
MH-14	D	36+38	710.0	699.23	--	48"	92"	--	--	--	--	699.44	18"	--	--	--	--	--	--

INTERCEPTOR PIPE - CLASS III  
 INLET PIPE - CLASS II  
 OUTLET PIPE - SEE OUTLET PROFILES



# GRAVITY STORM DRAINAGE SYSTEM

SCALE: NONE

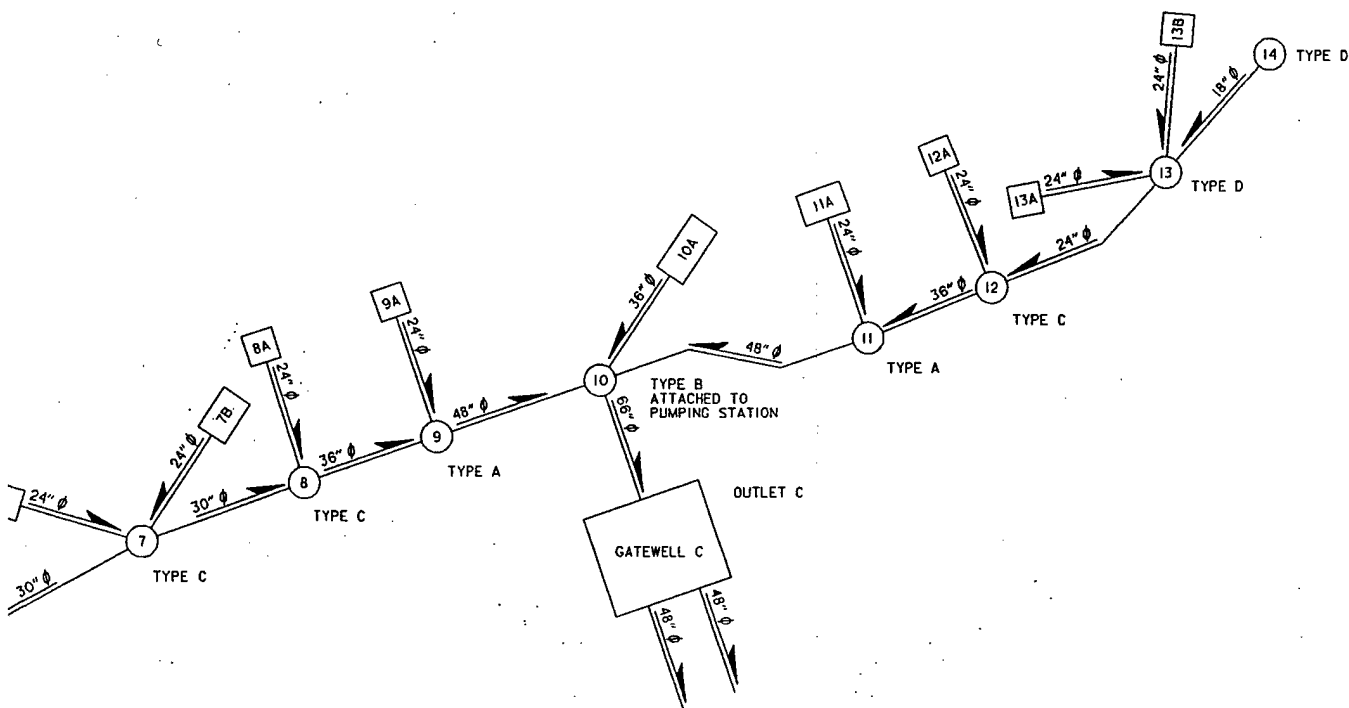
## LEGEND:

④ MANHOLE

4A INLET

— R.C.P.

PIPE E	RT.	DIA.	ANGLE (DEGREES+)			STRUCTURE NO.	REMARKS
			$\alpha$	$\beta$	$\gamma$		
--	--	--	197	--	--	MH-1	
5.73	24"	--	--	37	106	MH-2	INCREASER AT PIPE A
--	--	--	--	90	--	MH-3	INCREASER AT PIPE A
--	--	--	--	90	--	MH-4	INCREASER AT PIPE A
--	--	--	--	90	--	MH-5	INCREASER AT PIPE A - NO ARCH
--	--	--	--	138	--	MH-6	
5.73	24"	173	40	106	--	MH-7	
--	--	178	92	--	--	MH-8	
--	--	--	90	--	--	MH-9	INCREASER AT PIPE A
--	--	--	162	--	--	MH-10	
--	--	--	90	--	--	MH-11	INCREASER AT PIPE A
--	--	179	90	--	--	MH-12	
4.73	24"	180	37	106	--	MH-13	
--	--	--	--	--	--	MH-14	

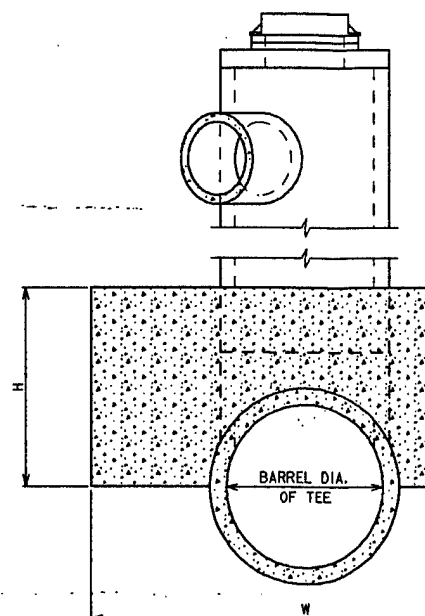


OUTLET B

# REFERENCES:

TYPE A MANHOLES \_\_\_\_\_ 5/216  
 TYPE B, C AND D MANHOLES & MANHOLE 10 \_\_\_\_\_ 5/217

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY          ST. PAUL DISTRICT, CORPS OF ENGINEERS          ST. PAUL, MINNESOTA</p>					
<p>DESIGNED: NRH          CHECKED: GRS          DRAWN: LKT</p>		<p>DESIGN MEMORANDUM NO. 2          CHASKA STAGE 4          FLOOD CONTROL - MINNESOTA RIVER          CHASKA, MINNESOTA          INTERIOR DRAINAGE          MANHOLES AND INLETS          MANHOLE SCHEDULE &amp; GRAVITY STORM DRAINAGE SYSTEM</p>			
<p>DATE: MARCH 1991</p>		<p>CAD FILE NAME: NCSDR215.DGN</p>		<p>DRAWING NUMBER:          M34-CH-R-5/215</p>	<p>SHT 16          OF 31</p>

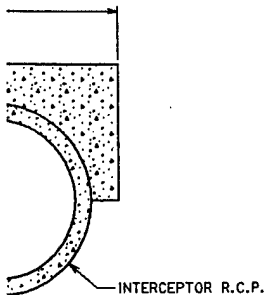
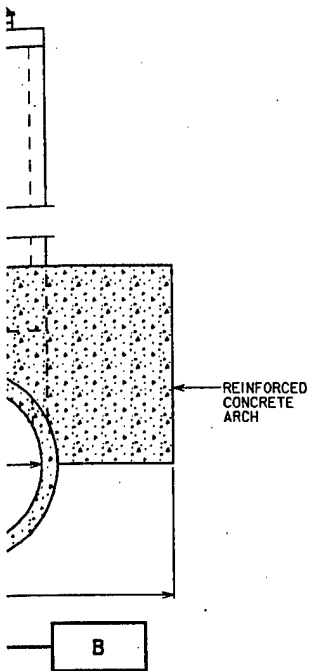


RIM ELEVATION  
 6"  
 27" DIA.  
 48" DIA.  
 5"  
 VARIES  
 12"  
 PIPE A  
 FLOW  
 INCREASER  
 ELEVATION A  
 8'-0"  
 MIN. LAYING LENGTH OF TEE  
 STANDARD TEE  
 PIPE B  
 ALL JOINTS IN MANHOLE TO HAVE "O" RING RUBBER GASKETS.

NEENAH R1642 FRAME AND COVER OR EQUAL LETTERED, "STORM SEWER", WITH 2 CONCEALED PICK HOLES.  
 MIN. OF 2, MAX. OF 6 CONCRETE ADJUSTMENT RINGS WITH FULL BED OF MORTAR BETWEEN EACH.  
 6" PRECAST REINFORCED CONC. MANHOLE SLAB WITH #4 BARS @ 5" O.C. EACH WAY AND 2 - #4 BARS AT ALL SIDES OF OPENING.  
 MANHOLE STEPS, NEENAH R1981J OR EQUAL, 16" ON CENTER. ALUMINUM STEPS APPROVED.

**TYPICAL SECTION**  
**R.C.P. CONCRETE ARCH**  
SCALE:  $\frac{3}{8}" = 1'-0"$

INTERCEPTOR BETWEEN MANHOLES	W
1 - 2	6'-0"
2 - 3	7'-0"



SECTION  
REINFORCED CONCRETE ARCH  
1" = 1'-0"

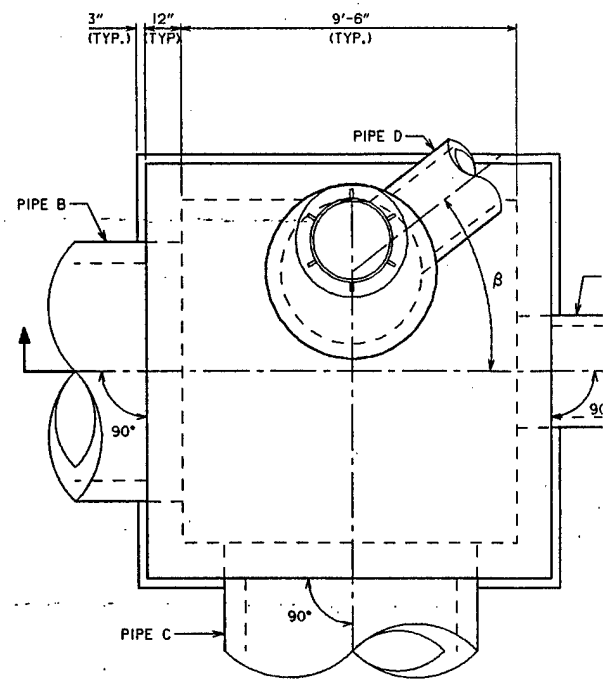
W	H
1'-0"	3'-0"
1'-0"	3'-10"

#### REFERENCES:

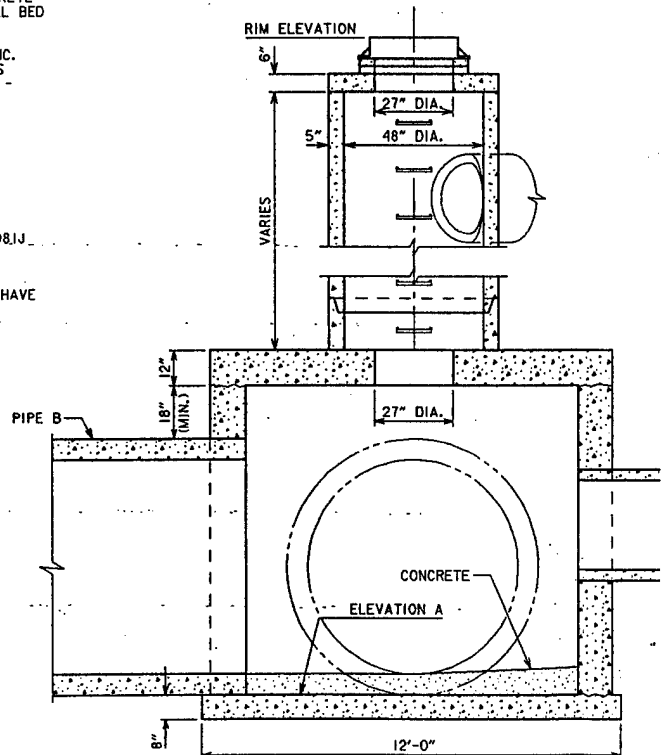
MANHOLE SCHEDULE AND SEQUENCE \_\_\_\_\_ 5/215

SYMBOL		DESCRIPTION		DATE	APPROVAL
		<b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA			
AE APPROVING OFFICIAL: _____		DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA			
DESIGNED: NRH CHECKED: GRS DRAWN: LKT	<b>INTERIOR DRAINAGE</b> MANHOLE PLAN AND SECTIONS TYPE A MANHOLE AND R.C.P. CONCRETE ARCH				
	DATE: MARCH 1991				
	SPEC NO: _____				
CAD FILE NAME: NCSPR216.DGN		DRAWING NUMBER:		SHT 17 OF 31	
		<b>M34-CH-R-5/216</b>			

2

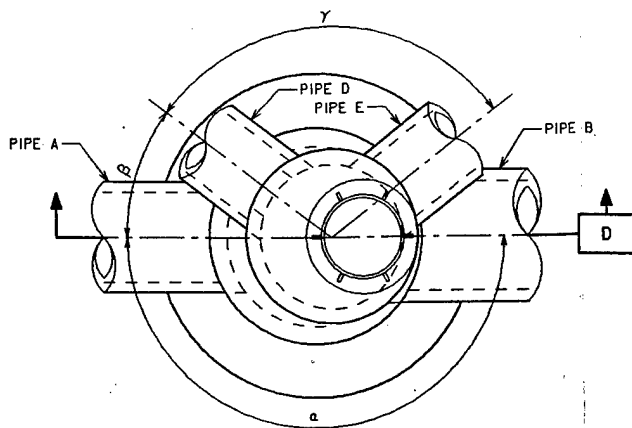
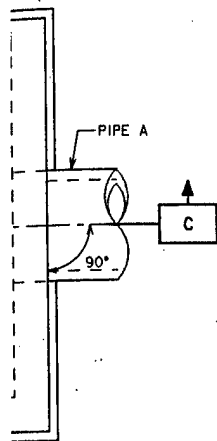


**PLAN**  
**TYPE B MANHOLES**  
SCALE:  $\frac{3}{8}" = 1'-0"$

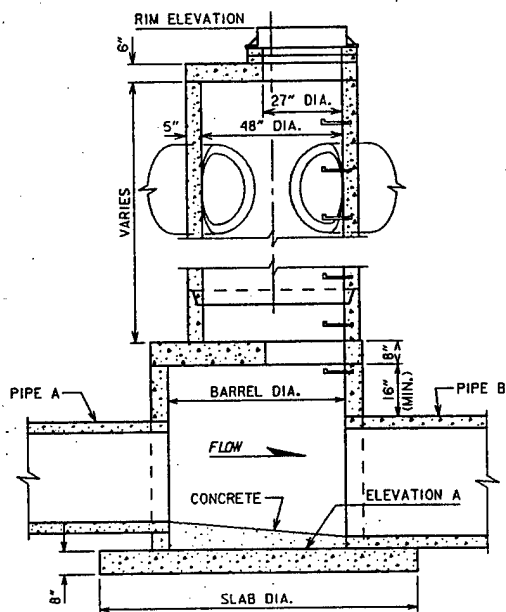


**SECTION**  
**MANHOLE 6 (OUTLET B)**  
**SCALE:  $\frac{3}{8}"=1'-0"$**

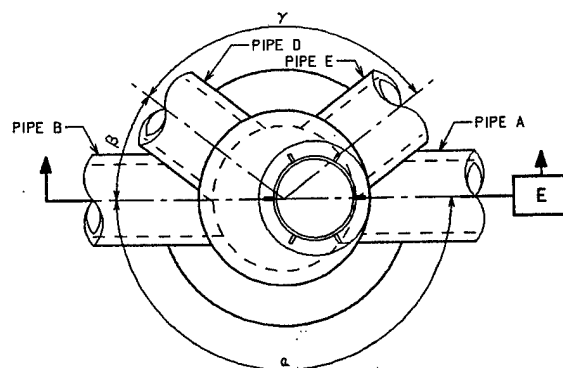




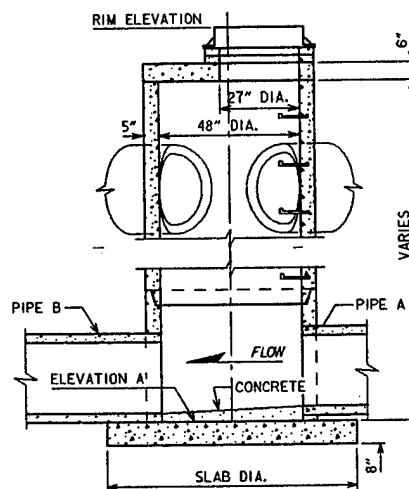
PLAN  
TYPE C MANHOLE  
SCALE:  $\frac{3}{8}" = 1'-0"$



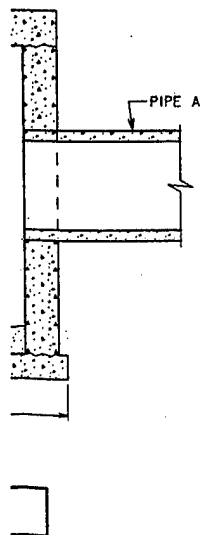
SECTION  
TYPE C MANHOLE  
SCALE:  $\frac{3}{8}" = 1'-0"$



PLAN  
TYPE D MANHOLE  
SCALE:  $\frac{3}{8}" = 1'-0"$



SECTION  
TYPE D MANHOLE  
SCALE:  $\frac{3}{8}" = 1'-0"$

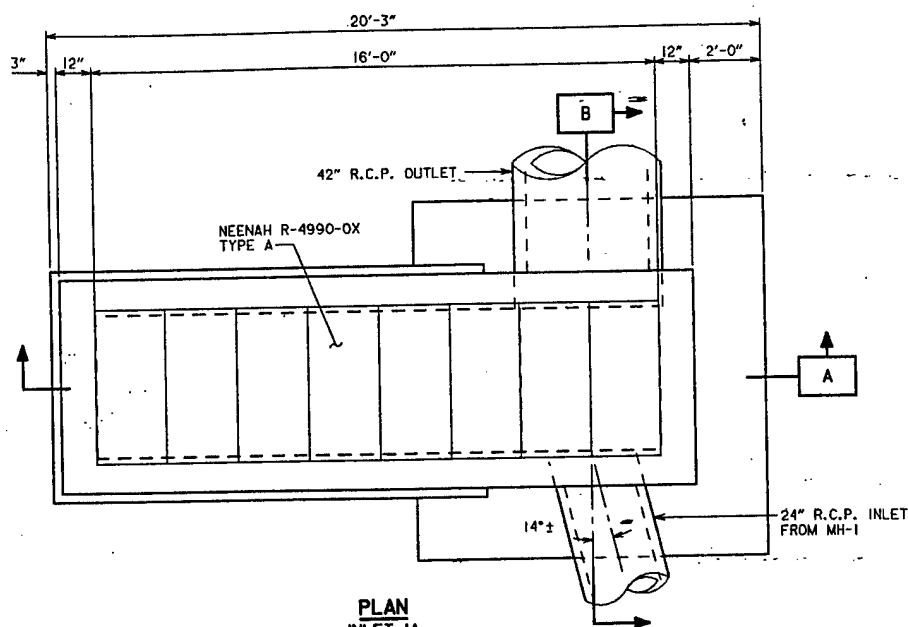


1 0 2 4 6  
SCALE:  $\frac{3}{8}" = 1'-0"$

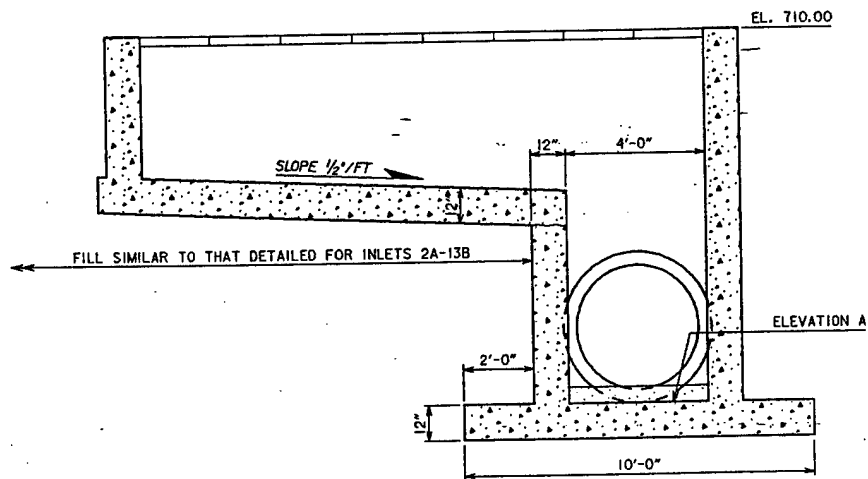
#### REFERENCES:

MANHOLE SCHEDULE AND SEQUENCE 5/215

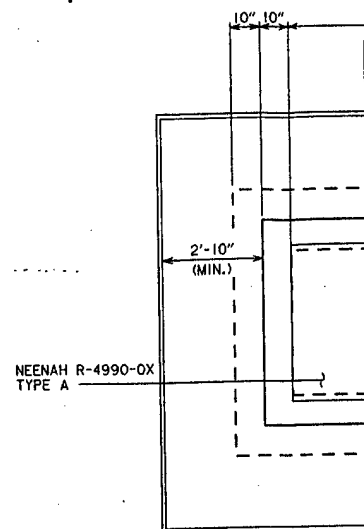
SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA</p>			
DESIGNED: NRH		CHASKA PROJECT			
CHECKED: GRS		INTERIOR DRAINAGE			
DRAWN: LKT		MANHOLE PLANS AND SECTIONS			
DESIGNED:		TYPE B, C, AND D			
CHECKED:		CAD FILE NAME: NCSPPR217.DGN		DRAWING NUMBER:	
DATE: MARCH 1991		SPEC NO:		M34-CH-R-5/217	
				SHT 18 OF 31	



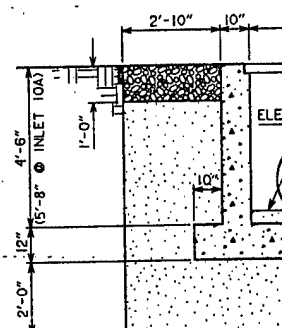
PLAN  
INLET 1A  
SCALE: 3/8" = 1'-0"



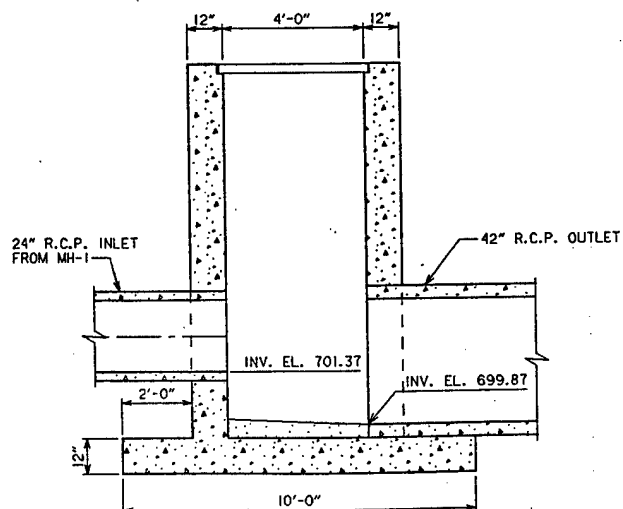
SECTION  
INLET 1A  
SCALE: 3/8" = 1'-0"



INLET  
SCALE



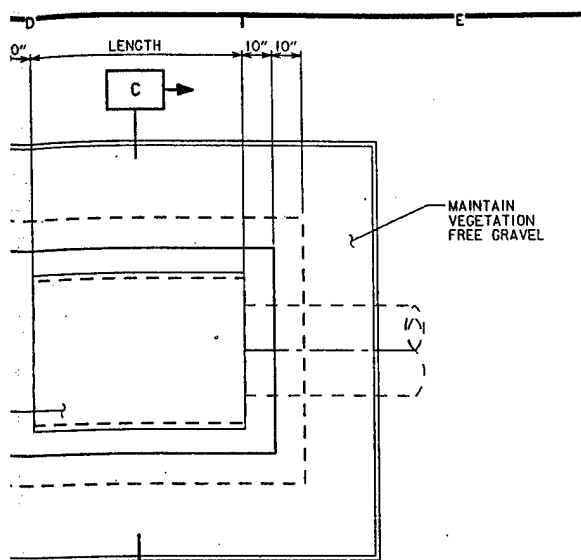
SECTION  
INLETS 2A-13B  
SCALE: 3/8" = 1'-0"



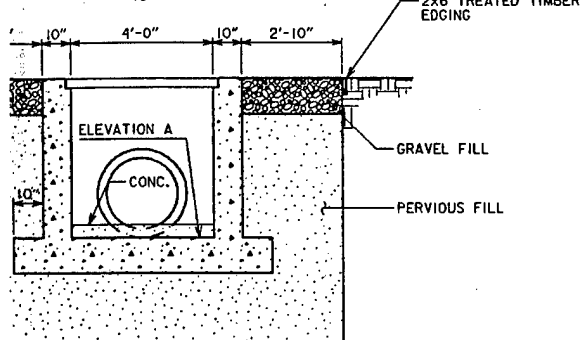
SECTION  
INLET 1A  
SCALE: 3/8" = 1'-0"

TYPICAL SE  
FILL AROUND  
INLETS 1A  
SCALE: 3/8" =

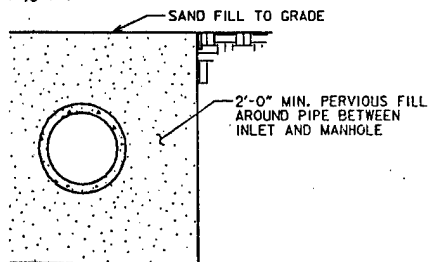
INLET SCHEDULE					
STRUCTURE NO.	TOP OF GRATING EL.	ELEVATION A	OUTLET PIPE INVERT EL.	OUTLET PIPE DIAMETER	LENGTH
INLET 1A	710.0	699.49	699.87	42"	16'
INLET 2A	710.0	705.50	705.75	24"	6'
INLET 2B	710.0	705.50	705.75	24"	6'
INLET 3A	710.0	705.50	705.75	24"	10'
INLET 4A	710.0	705.50	705.75	24"	12'
INLET 5A	710.0	705.50	705.75	24"	12'
INLET 6A	714.0	709.50	709.75	24"	8'
INLET 7A	711.0	706.50	706.75	24"	6'
INLET 7B	711.0	706.50	706.75	24"	6'
INLET 8A	710.0	705.50	705.75	24"	4'
INLET 9A	709.0	704.50	704.75	24"	4'
INLET 10A	708.0	702.33	702.67	36"	8'
INLET 11A	708.0	703.50	703.75	24"	6'
INLET 12A	708.0	703.50	703.75	24"	4'
INLET 13A	709.0	704.50	704.75	24"	4'
INLET 13B	709.0	704.50	704.75	24"	4'



**PLAN**  
INLETS 2A-13B  
SCALE:  $\frac{3}{8}" = 1'-0"$



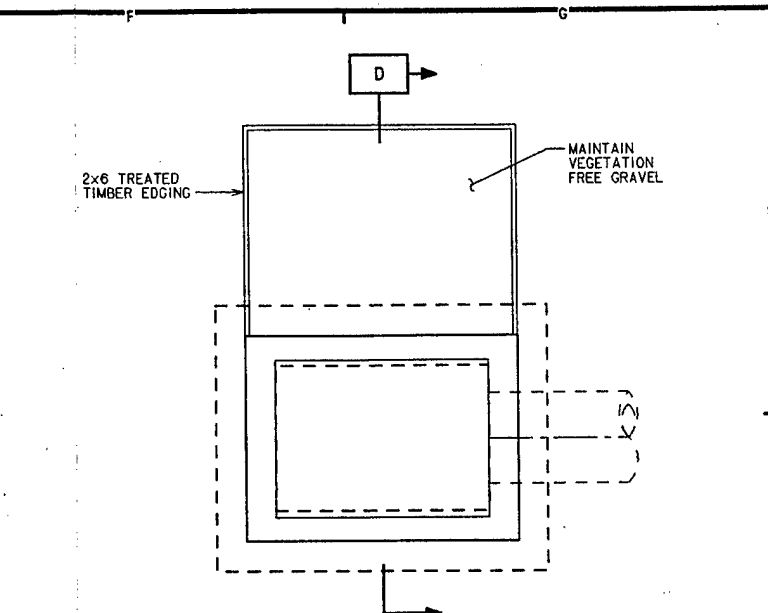
**SECTION**  
INLETS 2A-13B  
SCALE:  $\frac{3}{8}" = 1'-0"$



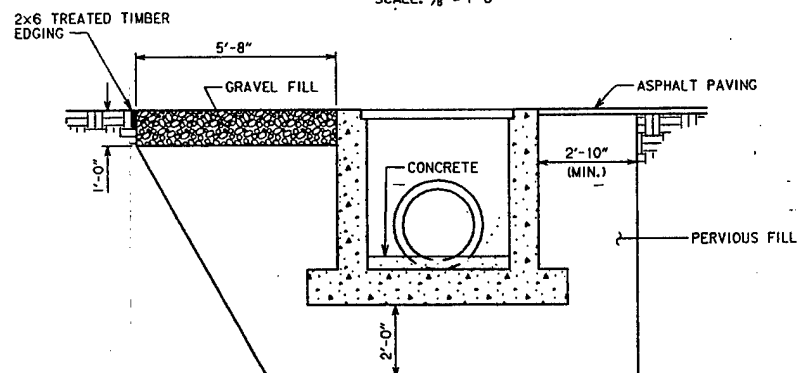
**TYPICAL SECTION**  
FILL AROUND PIPES  
INLETS 2A-13B  
SCALE:  $\frac{3}{8}" = 1'-0"$

LENGTH	REMARKS
16'	
8'	
6'	
10'	
12'	
12'	
8'	
6'	
6'	
4'	
4'	
8'	
6'	
4'	
4'	
4'	

SCALE:  $\frac{3}{8}" = 1'-0"$



**PLAN**  
OPTIONAL FILL - INLETS 2A-13B  
SCALE:  $\frac{3}{8}" = 1'-0"$

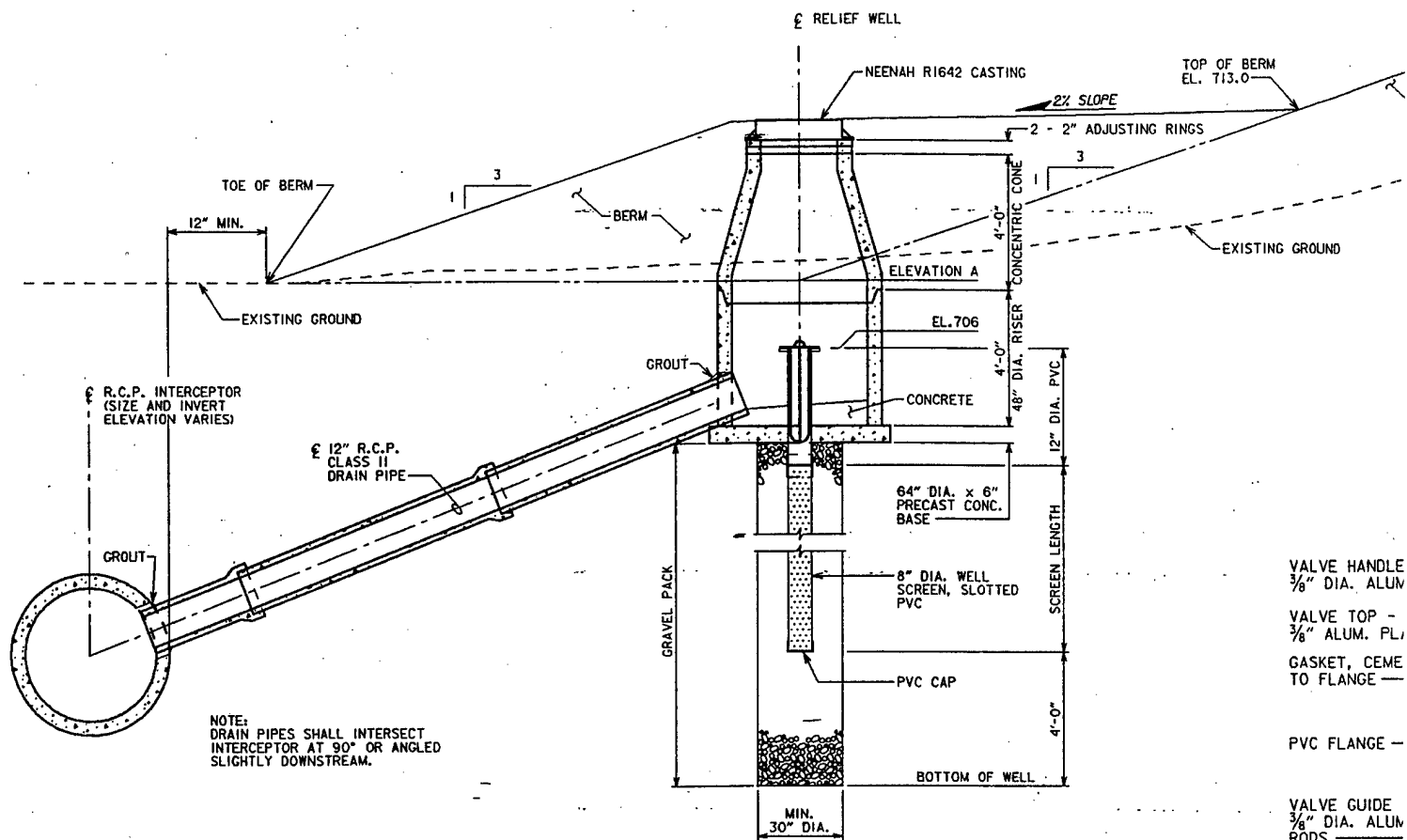


**SECTION**  
OPTIONAL FILL - INLETS 2A-13B  
SCALE:  $\frac{3}{8}" = 1'-0"$

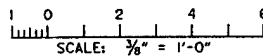
**NOTE:**

- OPTIONAL FILL TO BE USED IF INLET IS LOCATED IN ASPHALT PAVED STREET.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL: DESIGNED: NRH CHECKED: GRS DRAWN: LKT DESIGNED: JRC CHECKED: JRC		DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA INTERIOR DRAINAGE INLETS PLANS, SECTIONS & SCHEDULE			
CAD FILE NAME: NCSPR218.DGN DATE: MARCH 1991		DRAWING NUMBER: <b>MN34-CH-R-5/218</b>		SHT 19	OF 31



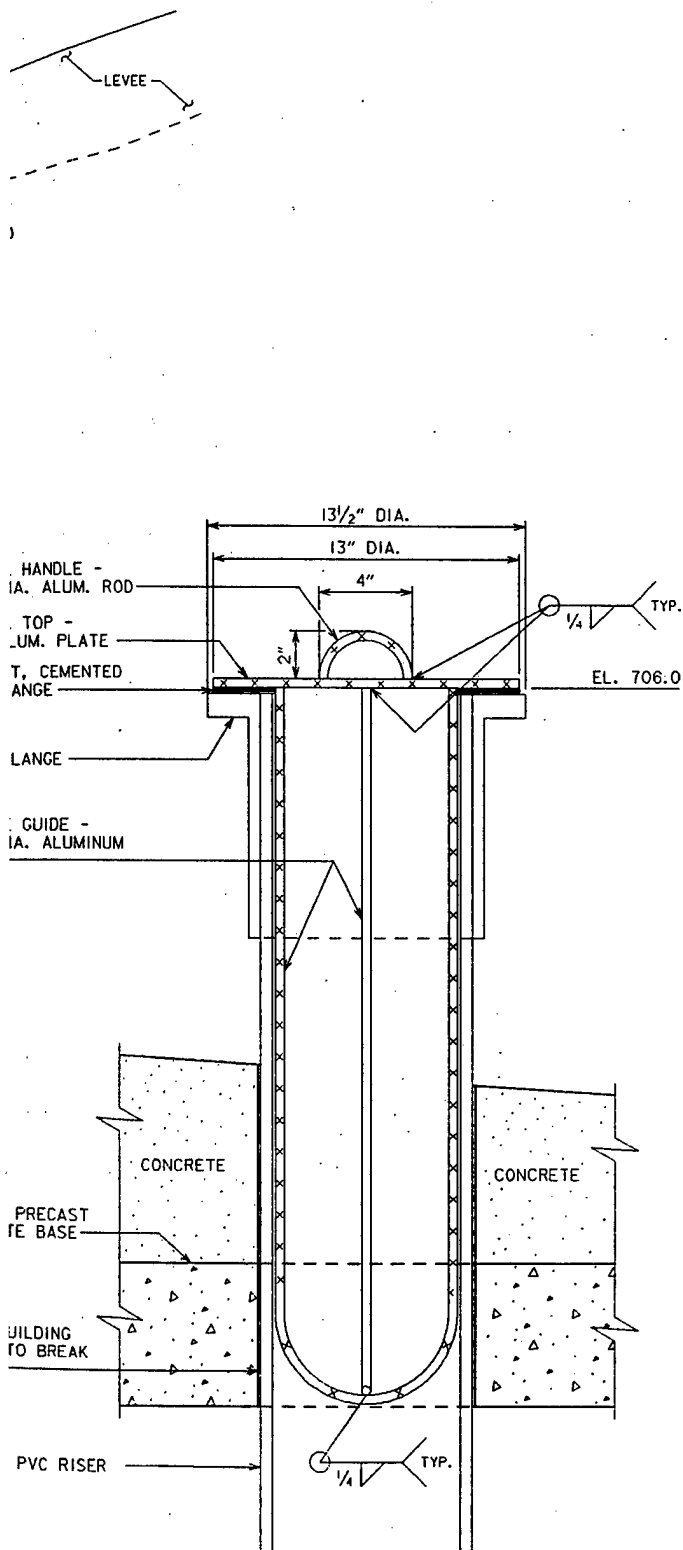
TYPICAL SECTION  
RELIEF WELL



TOP OF PRECAST  
CONCRETE BASE

WRAP BUILDING  
PAPER TO BREAK  
BOND

8" DIA. PVC RISER

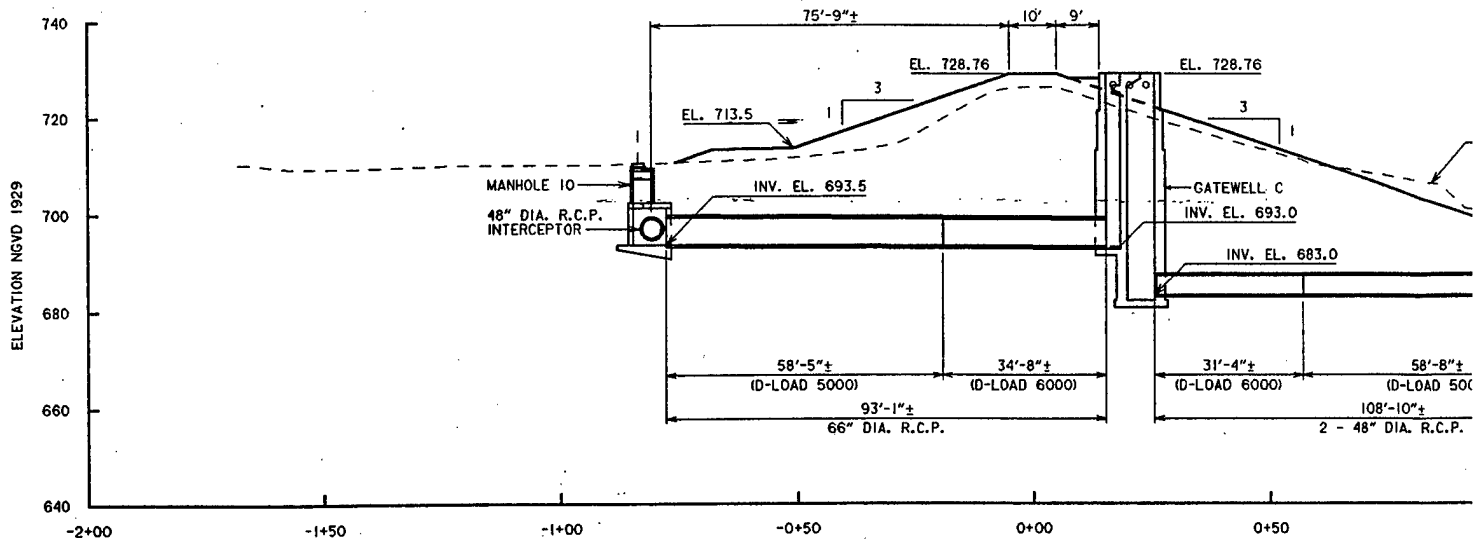


TYPICAL SECTION  
VALVE & RISER TOP

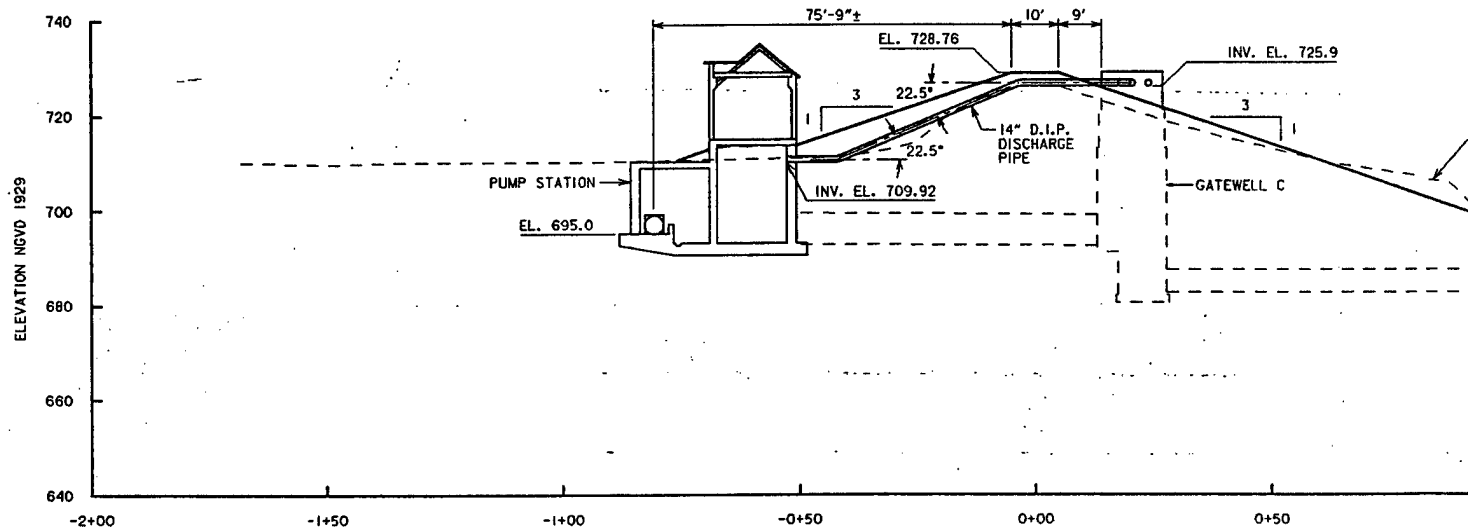
1" 0 4" 8"  
SCALE: 3" = 1'-0"

RELIEF WELL SCHEDULE				
WELL NO.	LEVEE STA.	ELEV. A	WELL SCREEN LENGTH (FT)	REMARKS
RW-1	60+66	709	10	
RW-2	59+40	709	38	
RW-3	59+00	709	38	
RW-4	58+20	709	38	
RW-5	57+40	709	38	
RW-6	56+60	709	38	
RW-7	55+80	709	39	
RW-8	54+66.5	709	39	
RW-9	53+92.5	709	39	
RW-10	53+18.5	709	39	
RW-11	52+44.5	709	39	
RW-12	51+70.5	709	48	
RW-13	51+03.5	709	48	
RW-14	50+36.5	709	48	
RW-15	49+69.5	709	48	
RW-16	49+02.5	709	48	
RW-17	48+35.5	709	60	
RW-18	47+89.5	709	60	
RW-19	47+43.5	708	60	
RW-20	46+97.5	708	60	
RW-21	46+51.5	708	60	
RW-22	46+05.5	708	60	
RW-23	45+59.5	708	60	
RW-24	45+13.5	708	60	
RW-25	44+67.5	708	60	
RW-26	44+21.5	708	59	
RW-27	43+49.7	708	59	
RW-28	42+77.5	708	59	
RW-29	42+05.5	708	59	
RW-30	41+33.5	708	59	
RW-31	40+61.5	708	59	
RW-32	39+89.5	710	59	
RW-33	38+87.5	710	59	
RW-34	37+85.5	710	59	
RW-35	36+83.5	710	59	
RW-36	35+81.5	710	59	

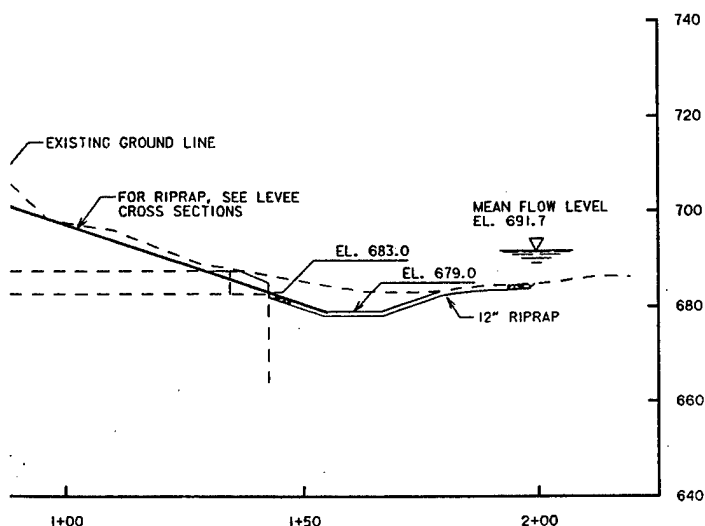
SYMBOL		DESCRIPTION		DATE	APPROVAL
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<p>DESIGNED: GRS CHECKED: GRS DRAWN: LKT</p>		<p>DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA INTERIOR DRAINAGE RELIEF WELLS SECTIONS AND SCHEDULE</p>			
<p>DESIGNED: JRC CHECKED: JRC</p>		<p>CAD FILE NAME: NCSDR219.DGN</p>		<p>DRAWING NUMBER: M34-CH-R-5/219</p>	
<p>DATE: MARCH 1991</p>		<p>SPEC NO:</p>		<p>SHT 20 OF 31</p>	

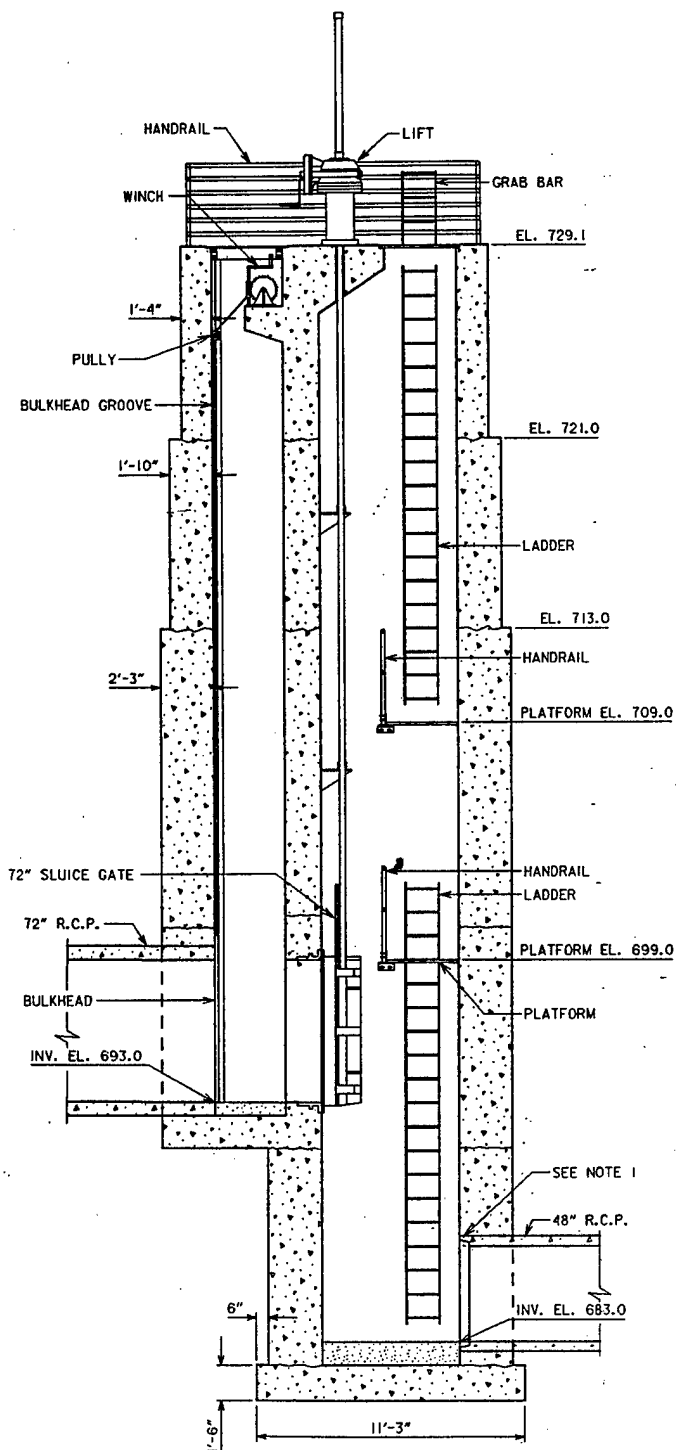


PROFILE A  
OUTLET C - STA. 47+94.6  
SCALE: 1" = 20'-0"



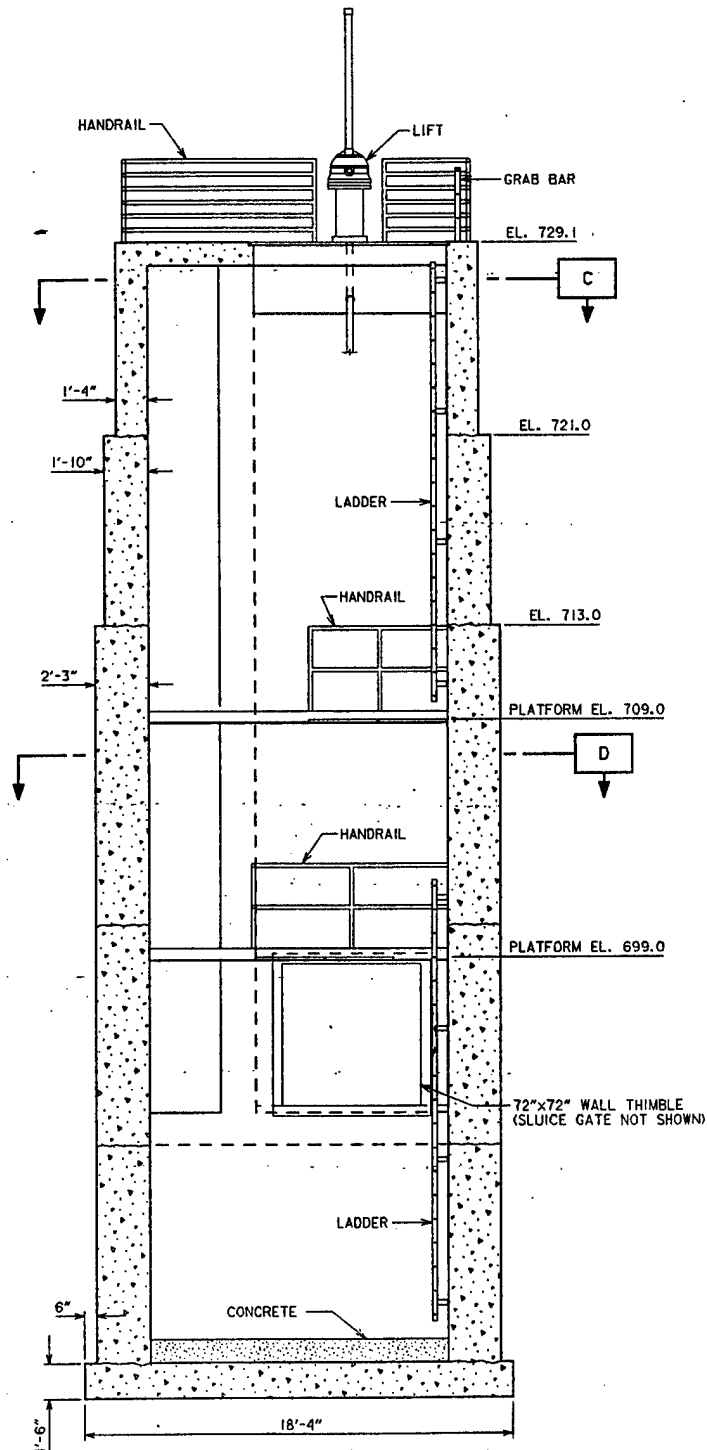
PROFILE B  
STA. 48+11.6  
SCALE: 1" = 20'-0"

[illegible]



**SECTION**  
STA. 55+88.45  
SCALE: 1/4"=1'-0"

A

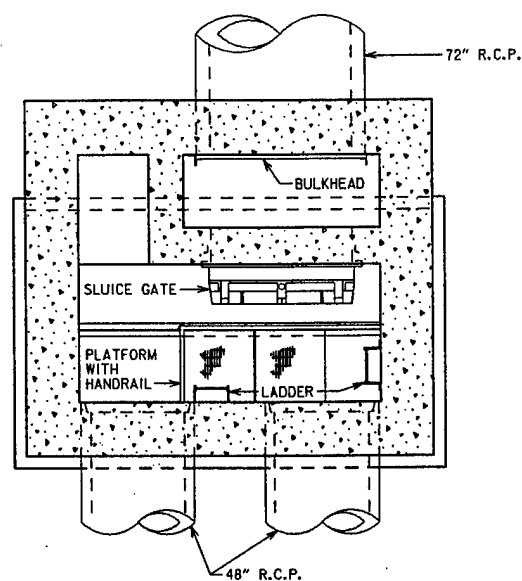
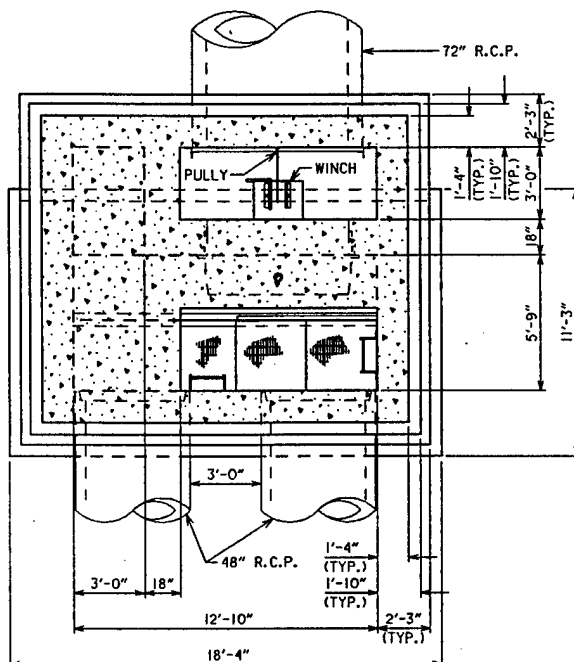
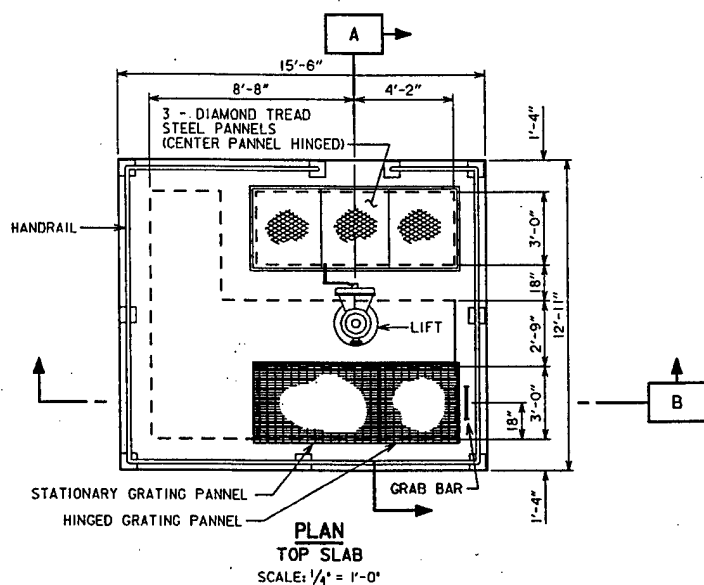


**SECTION**

SCALE: 1/4"=1'-0"

B





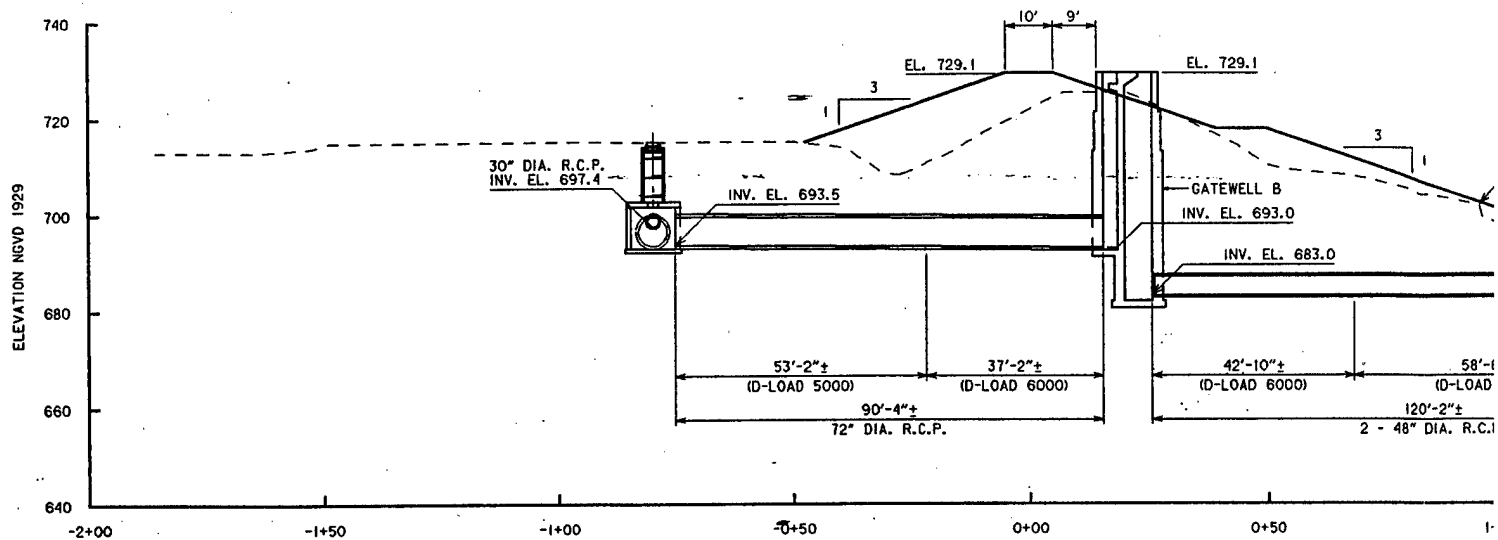
#### NOTES:

- FOR R.C.P. PROVIDE TONGUE AND GROVE JOINT, GROVE END AT THE OUTLET OF ALL CAST-IN-PLACE STRUCTURES. ALL OTHER R.C.P. JOINTS TO BE BELL AND SPIGOT. TYPE CX-4 O-RING RUBBER GASKET JOINT.

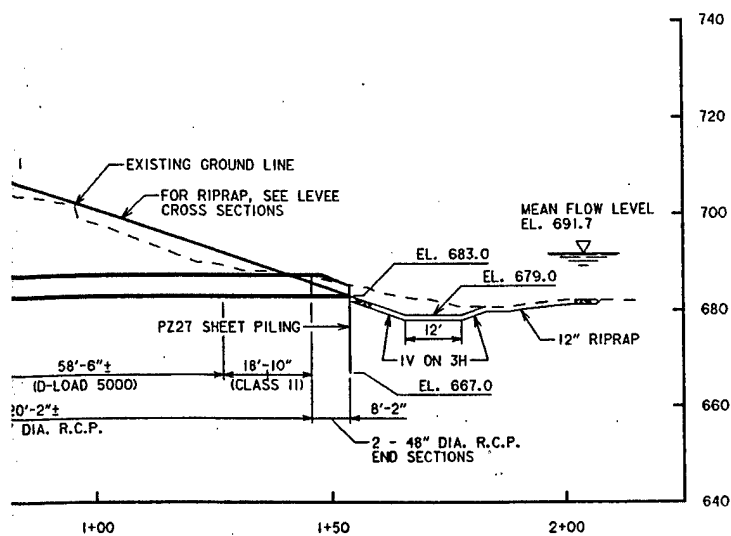
SYMBOL	DESCRIPTION	DATE	APPROVAL
<b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA			
AE APPROVING OFFICIAL:		DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER <b>CHASKA PROJECT</b> CHASKA, MINNESOTA	
DESIGNED: GRS CHECKED: GRS DRAWN: LKT		<b>INTERIOR DRAINAGE</b> <b>GATEWELL B</b> <b>PLAN AND SECTIONS</b>	
DATE: MARCH 1991		CAD FILE NAME: NCSPR222.DGN SPEC NO:	DRAWING NUMBER: <b>M34-CH-R-5/222</b> SHT 23 OF 31

0 4 8  
SCALE: 1/4" = 1'-0"

2



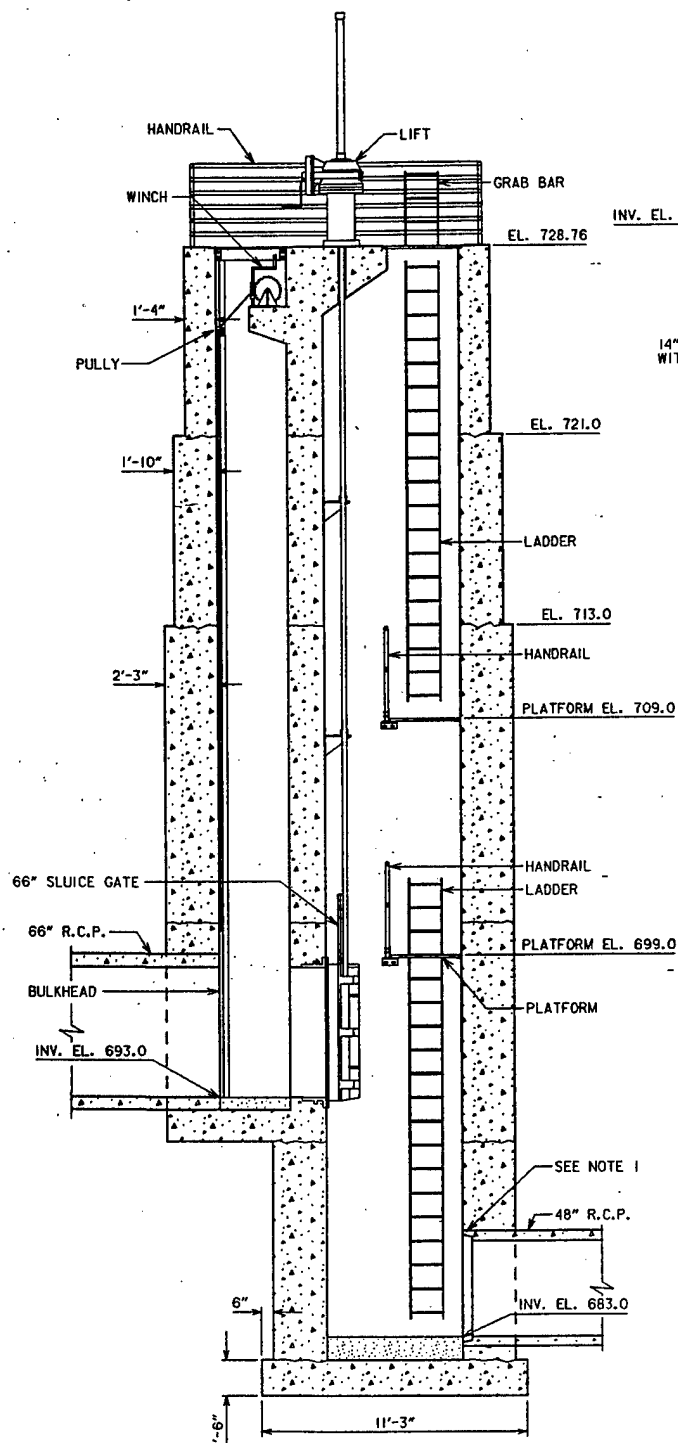
**PROFILE**  
**OUTLET B - STA. 55+88.45**  
 SCALE: 1" = 20'-0"



SYMBOL		DESCRIPTION		DATE	APPROVAL
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AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM DESIGN MEMORANDUM NO. 2 FLOOD CONTROL - MINNESOTA RIVER CHASKA STAGE 4 CHASKA, MINNESOTA INTERIOR DRAINAGE OUTLET B PROFILE</p>			
DESIGNED	DESIGNED: GRS/NRH	CAD FILE NAME: NCGIR221.DGN		DRAWING NUMBER:	SHT 22
	CHECKED: GRS				
	DRAWN: LKT				
	DESIGNED:				
CHECKED:		SPEC NO:		M34-CH-R-5/221	OF 71
DATE: MARCH 1991					

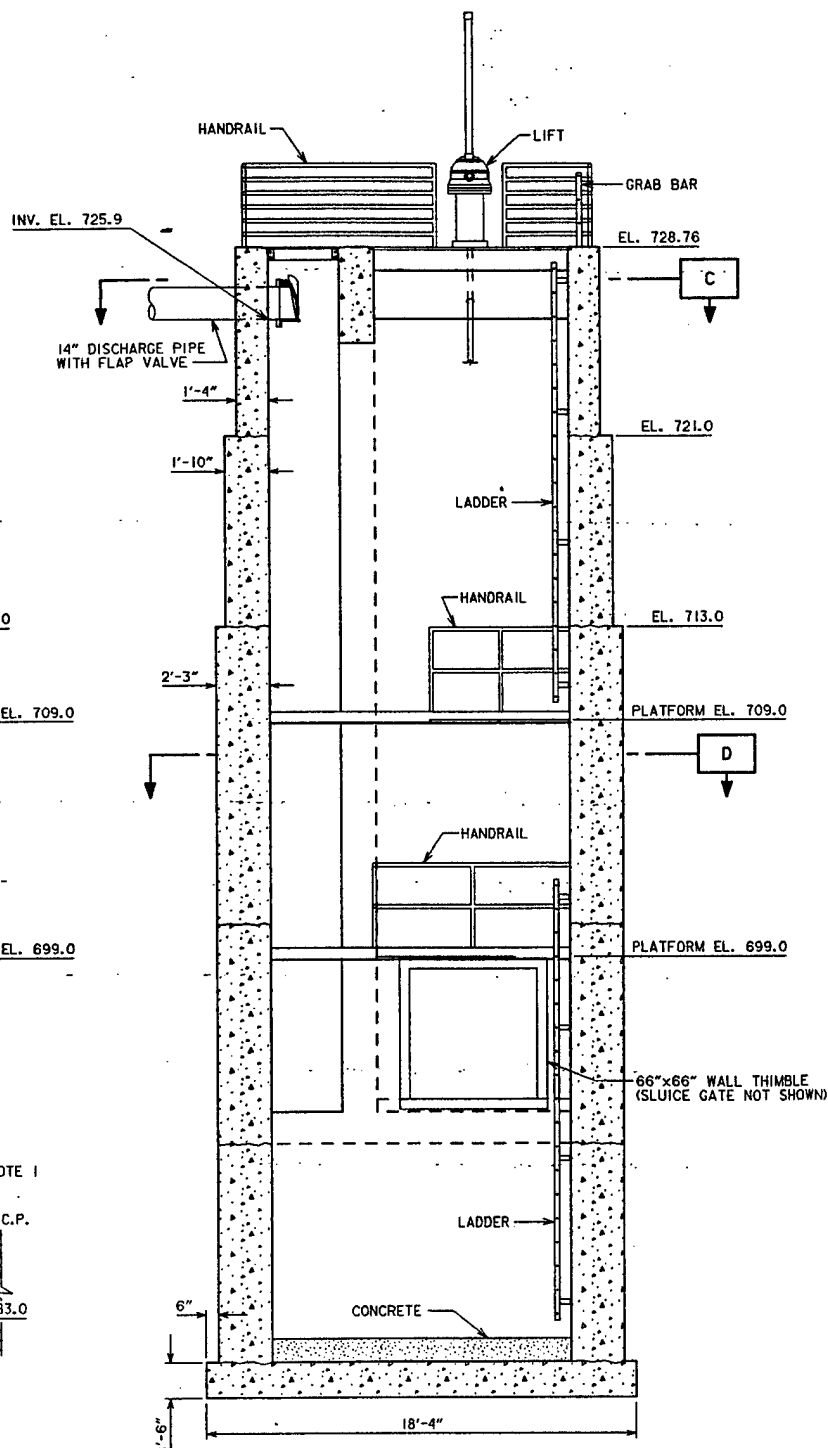
HANDR

3 - H  
TREAD  
PANNE



SECTION  
STA. 47+94.6  
SCALE: 1/4"=1'-0"

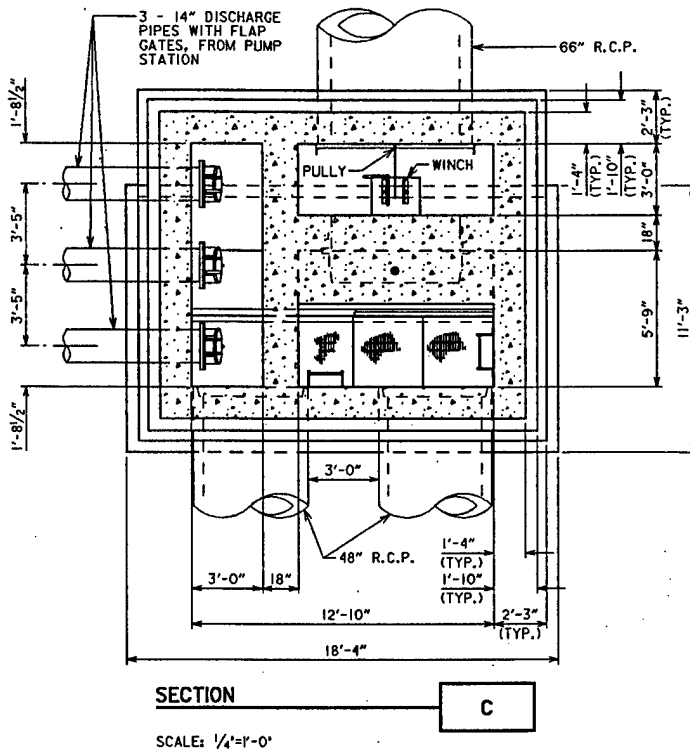
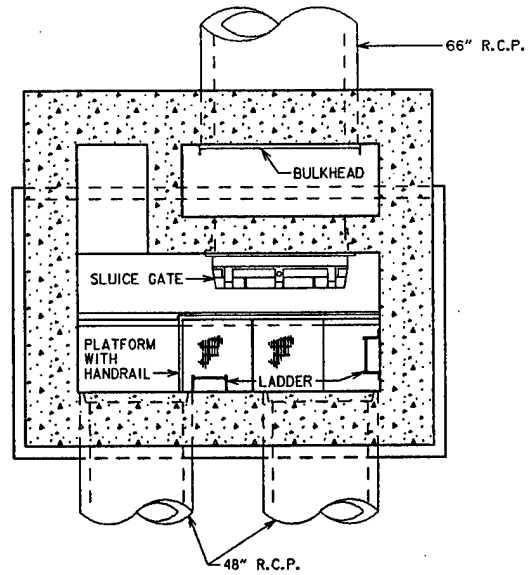
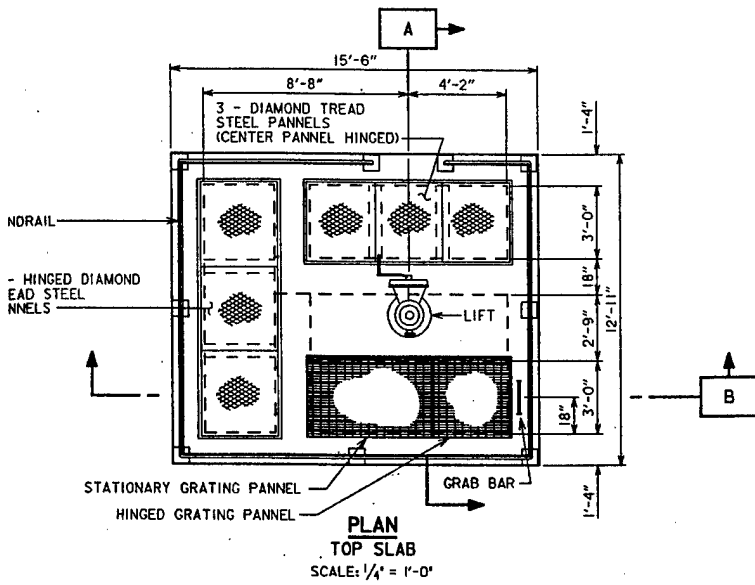
A



SECTION

SCALE: 1/4"=1'-0"

B



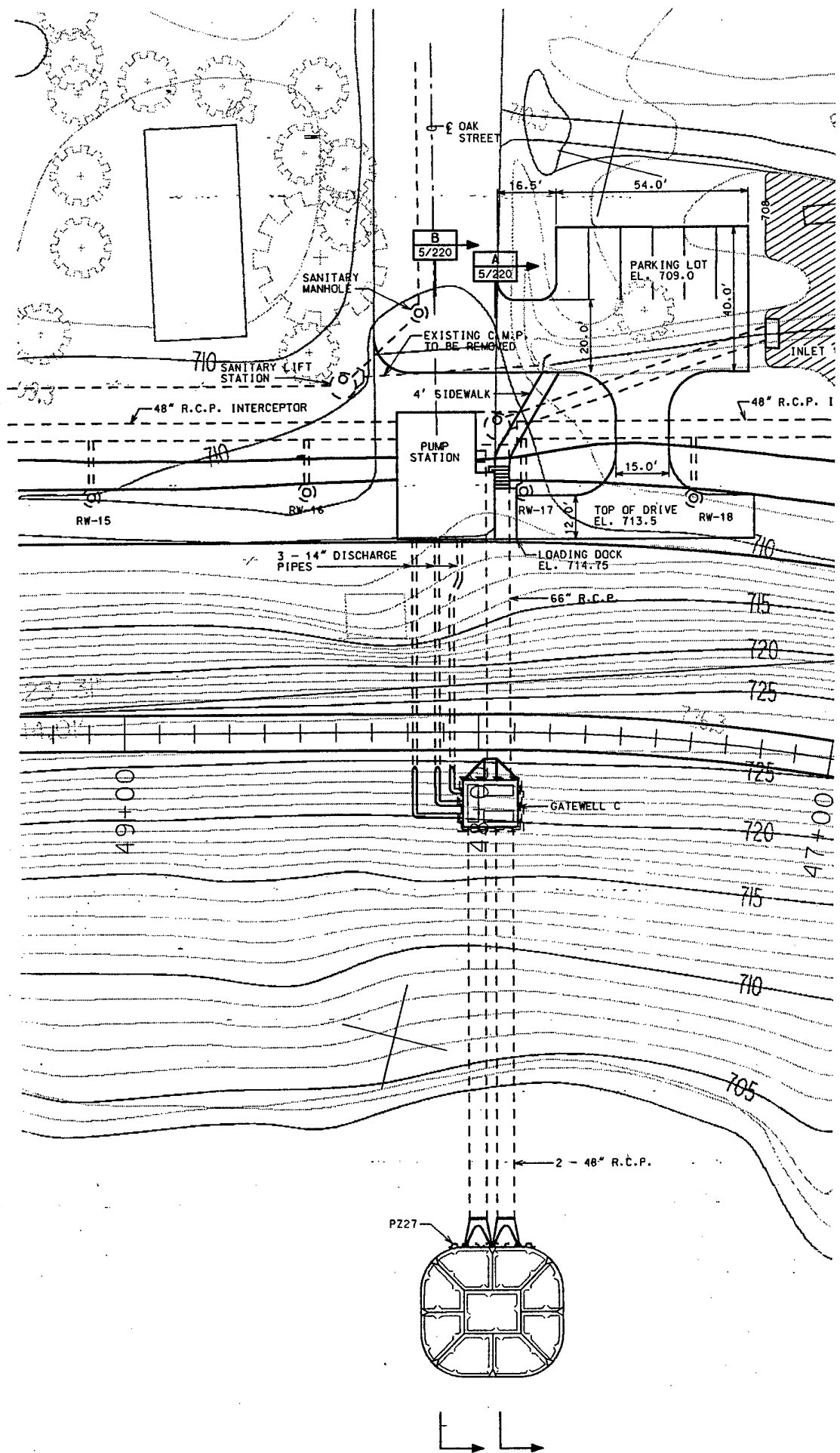
#### NOTES:

1. FOR R.C.P. PROVIDE TONGUE AND GROOVE JOINT, GROOVE END AT THE OUTLET OF ALL CAST-IN-PLACE STRUCTURES. ALL OTHER R.C.P. JOINTS TO BE BELL AND SPIGOT. TYPE CX-4 O-RING RUBBER GASKET JOINT.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL: _____		DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA <b>INTERIOR DRAINAGE</b> <b>GATEWELL C</b> <b>PLAN AND SECTIONS</b>			
DESIGNED: GRS CHECKED: GRS DRAWN: LKT _____	CAD FILE NAME: NCSPPR223.DGN		DRAWING NUMBER:		SHT 24
	DATE: MARCH 1991		SPEC NO:		OF 31
	M34-CH-R-5/223				

0 4 8  
SCALE: 1/4" = 1'-0"

2





FILL TO EL. 708.0

LET 10A

~~P. INTERCEPTOR~~

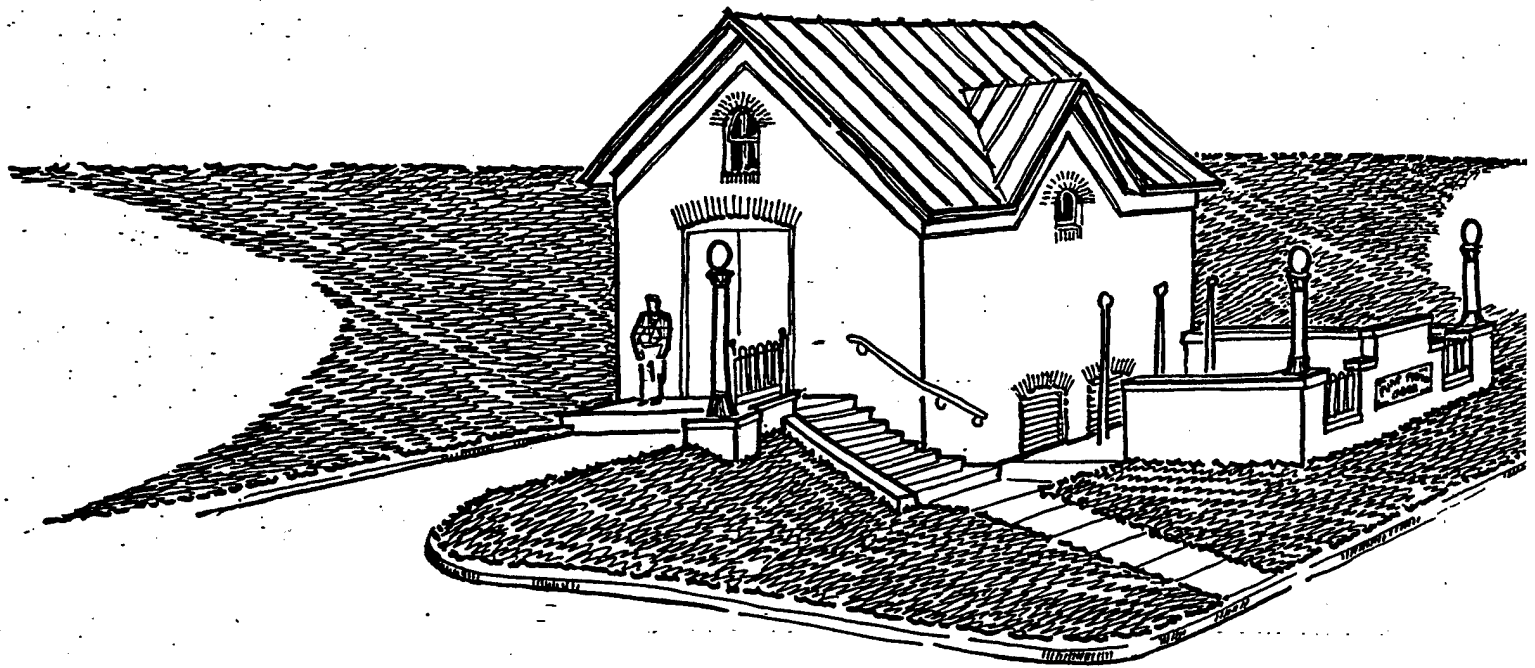
RW-19

-FOR RIPRAP AND FILL LINES  
SEE LEVEE CROSS SECTIONS

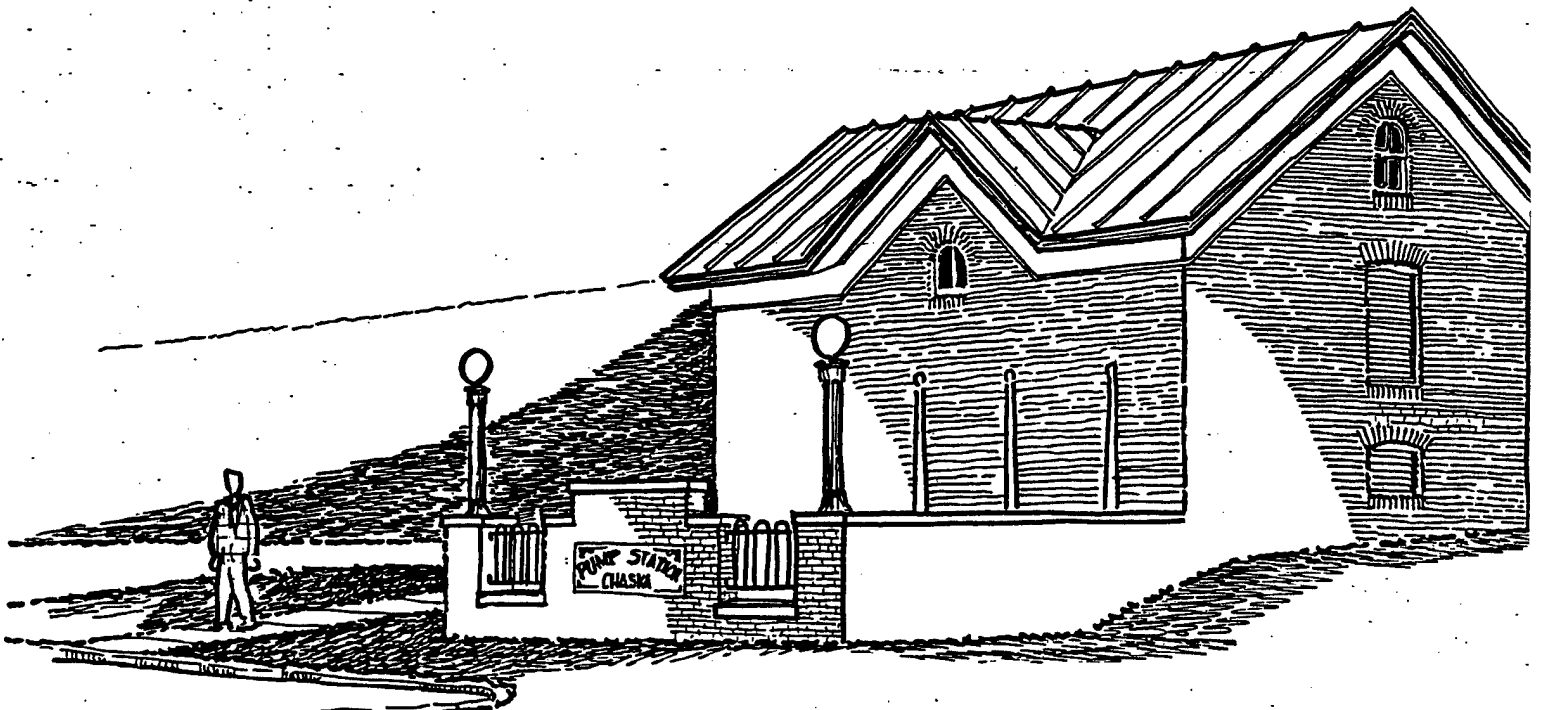


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SYMBOL		DESCRIPTION		DATE APPROVAL	
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AE APPROVING OFFICIAL:  		DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA <b>CHASKA PROJECT</b>  <b>PUMP STATION</b> OUTLET C SITE PLAN			
ED-D	DESIGNED: NRH	CAD FILE NAME: NCGIR224.DGN DRAWING NUMBER: M34-CH-R-5/224		SHT 25	
	CHECKED: GRS				
ED-GH	DRAWN: LKT			DATE: MARCH 1991 SPEC NO:	OF 31
	DESIGNED:				
	CHECKED:				

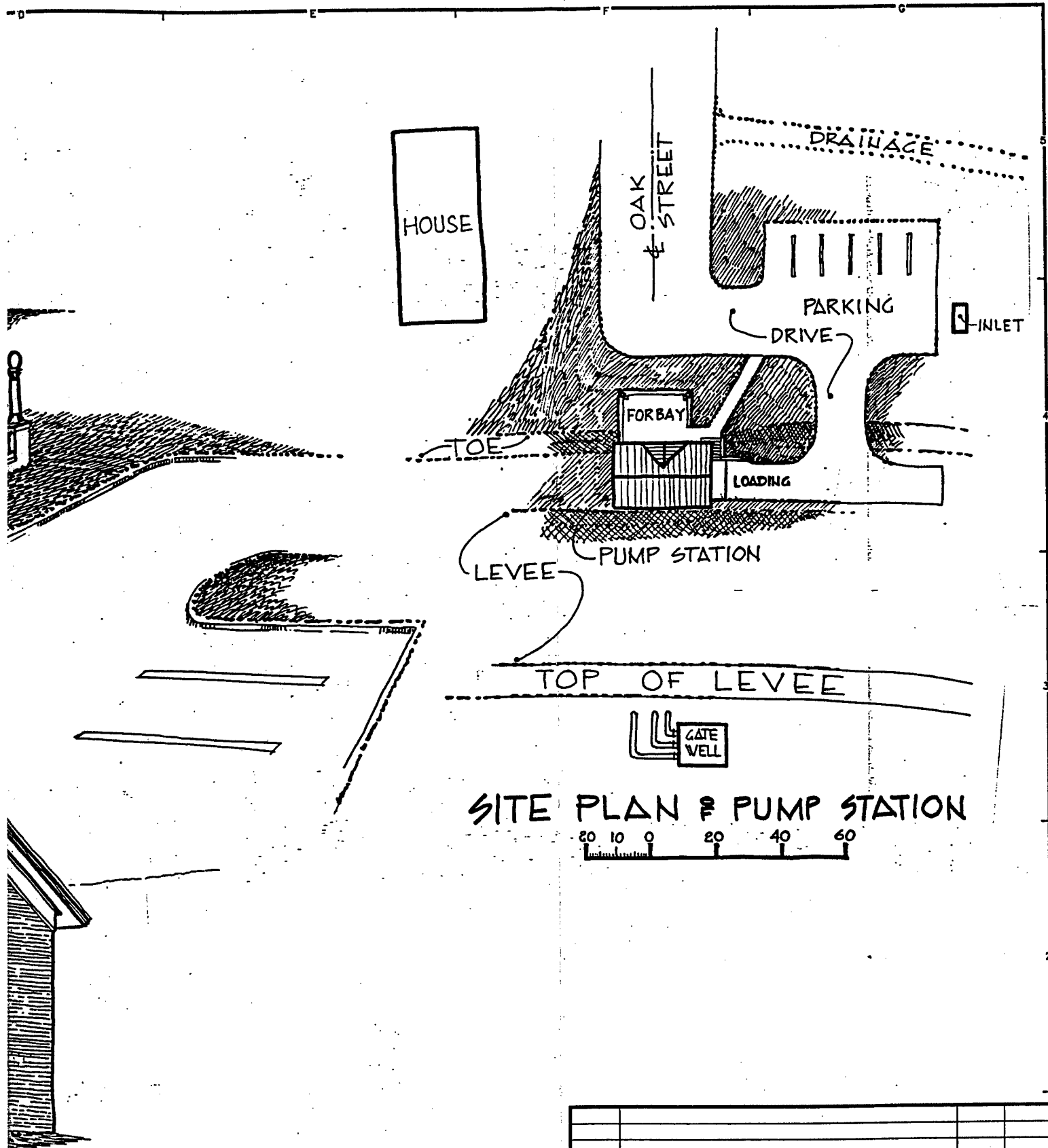


VIEW LOOKING S.W.



VIEW LOOKING





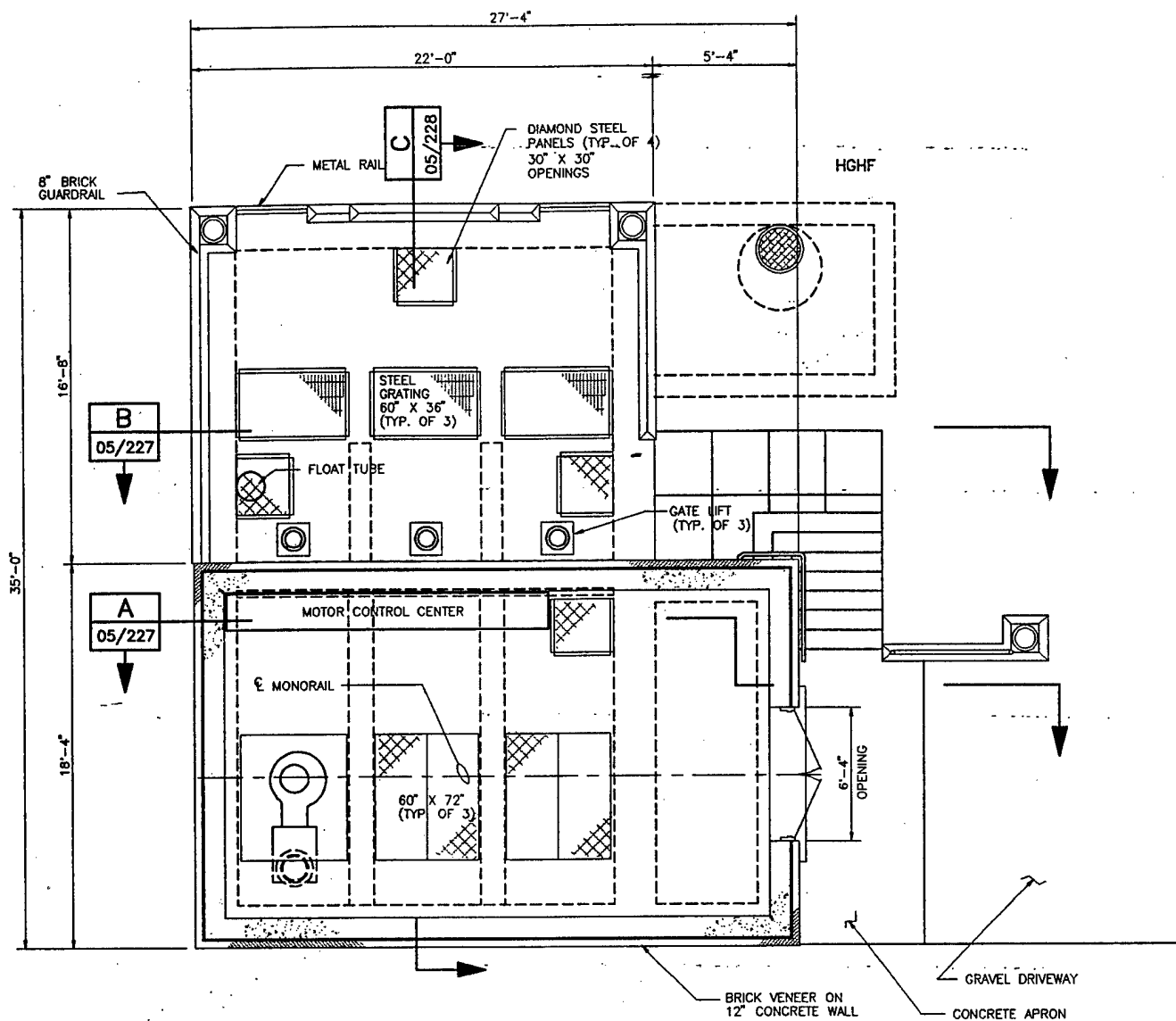
# SITE PLAN & PUMP STATION

20 10 0 20 40 60

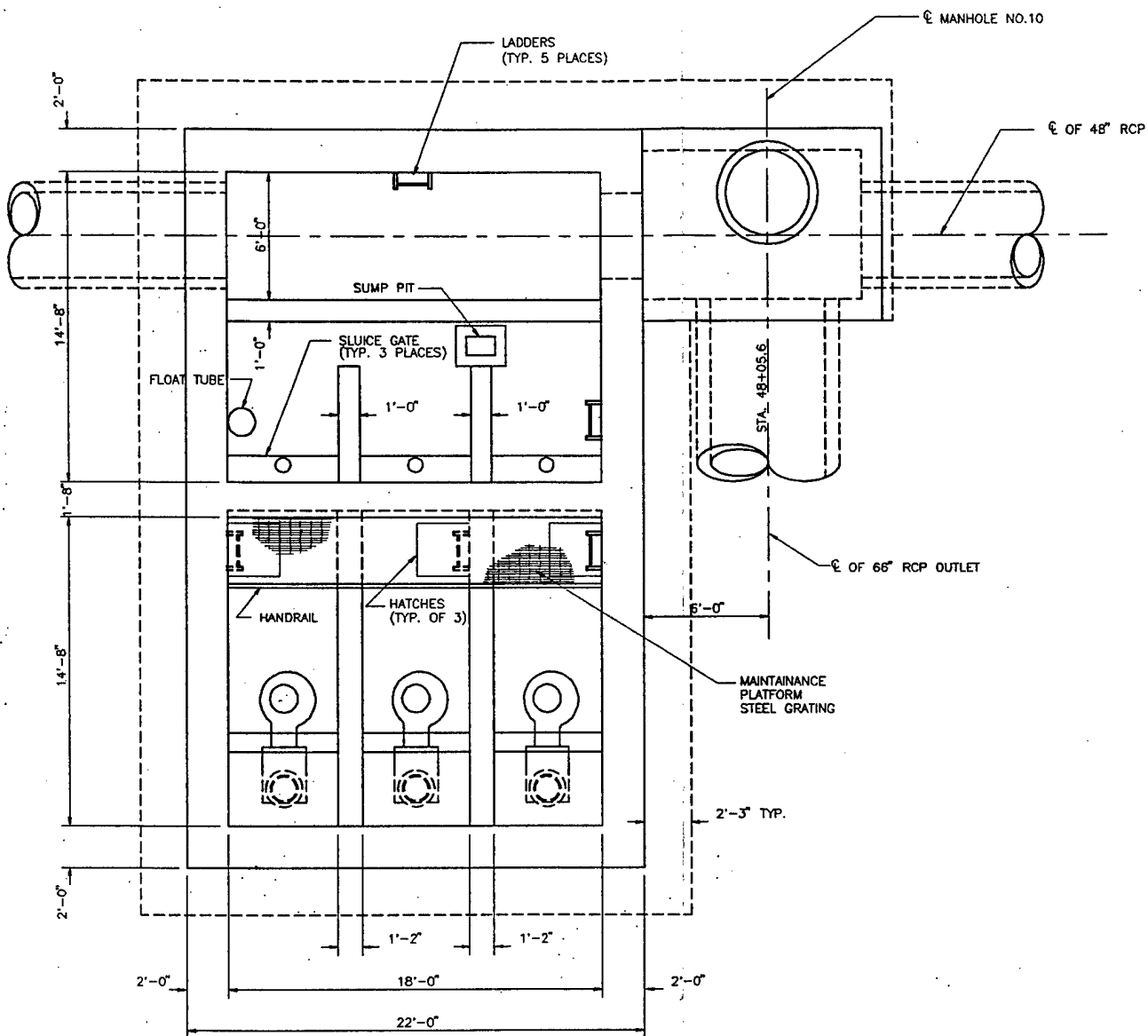
16 S. E.

2

SYMBOL		DESCRIPTION		DATE	APPROVAL
DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA					
AE APPROVING OFFICIAL: _____		DESIGN MEMORANDUM NO.2 CHASKA - STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA			
DESIGNED:	PRK/CG	PUMPING STATION SITE PLAN AND PERSPECTIVE SKETCHS			
	CHECKED: PRK/CG				
	DRAWN: CG/PPC				
	DESIGNED:				
CHECKED:		CAD FILE NAME: MN05R225.DWG	DRAWING NUMBER:	SHT 26	
DATE: 03-22-91		SPEC NO: SEE DWG. 05/200	M34-CH-R-05/225	OF 31	



**PLAN**  
AT OPERATING LEVEL OF PUMP CHAMBER

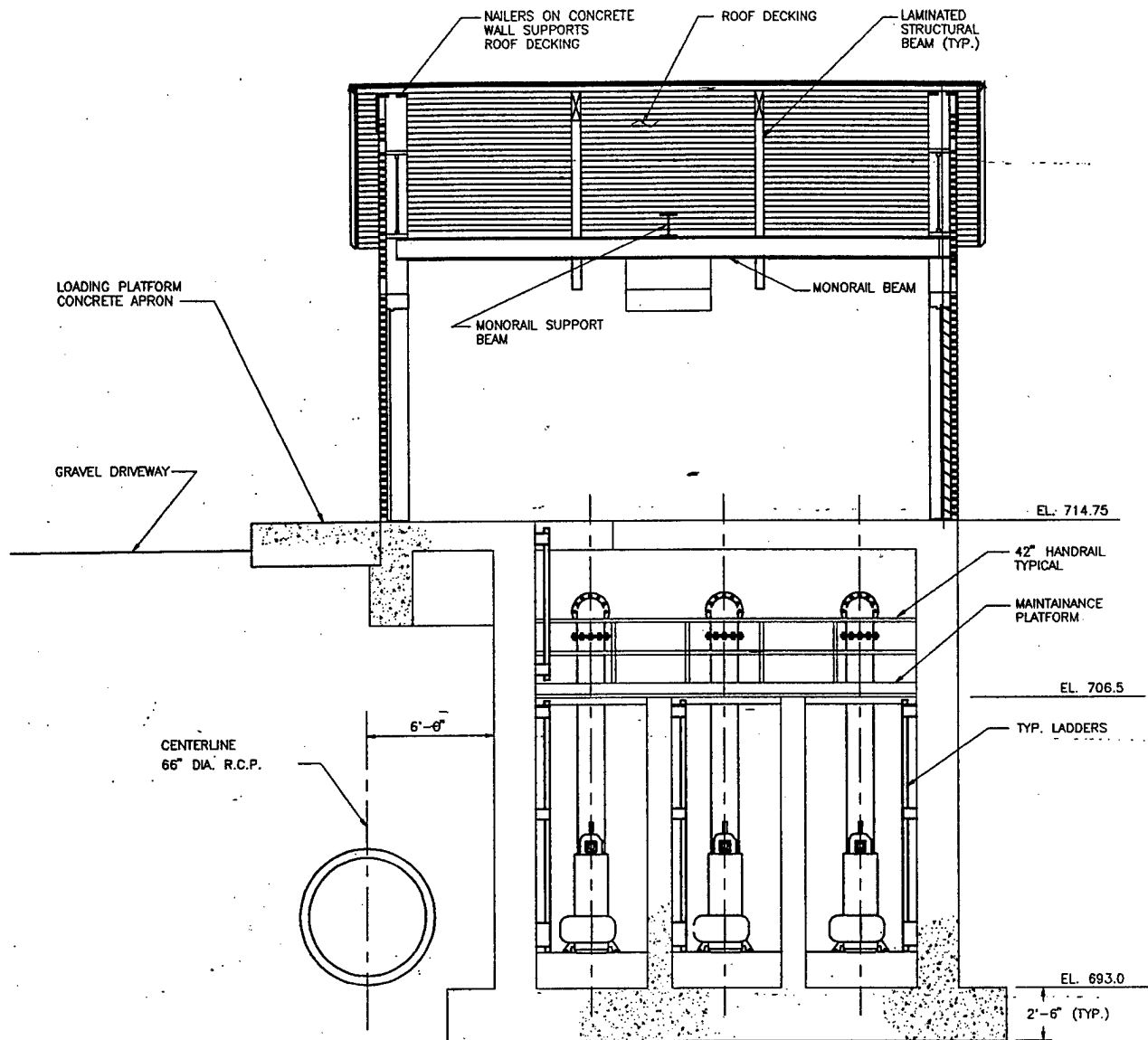


**PLAN**  
AT ELEV. 707.0

1 0 4 8  
SCALE: 1/4" = 1'-0"

2

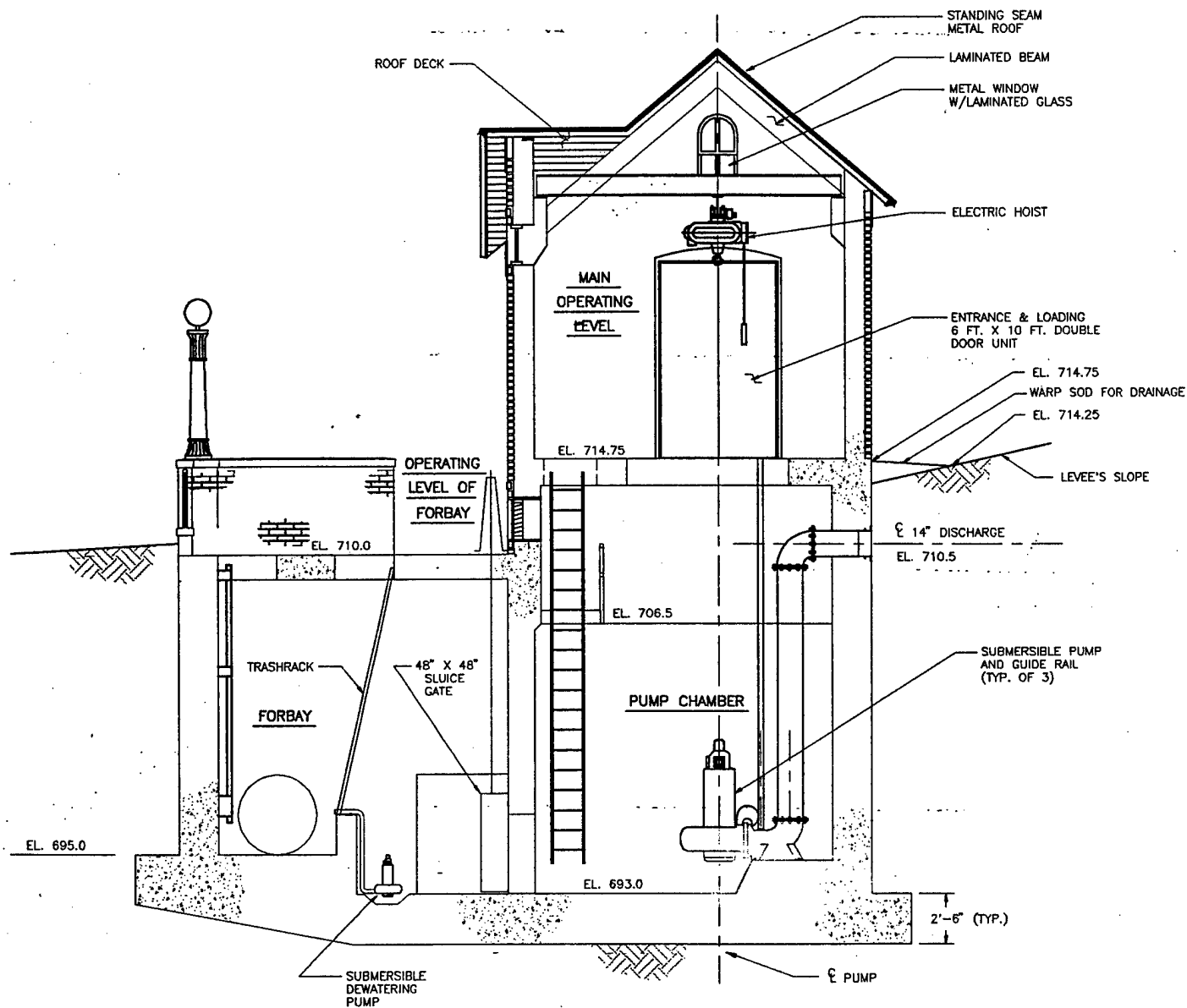
SYMBOL	DESCRIPTION	DATE	APPROVAL
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<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO.2 CHASKA - STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA</p>	
<p>DESIGNED: PRK/CG CHECKED: PRK/CG DRAWN: PPC</p>	<p align="center"><b>PUMPING STATION LAYOUT PLANS</b></p>		
<p>DESIGNED: CHECKED: DATE: 03-22-91</p>	<p>CAD FILE NAME: MN05R226.DWG SPEC NO: SEE DWG. 05/200</p>	<p>DRAWING NUMBER: <b>M34-CH-R-05/226</b></p>	<p>SHT 27 OF 31</p>



SECTION  
 MAIN OPERATING LEVEL  
 AND PUMP CHAMBER

A  
 05/226





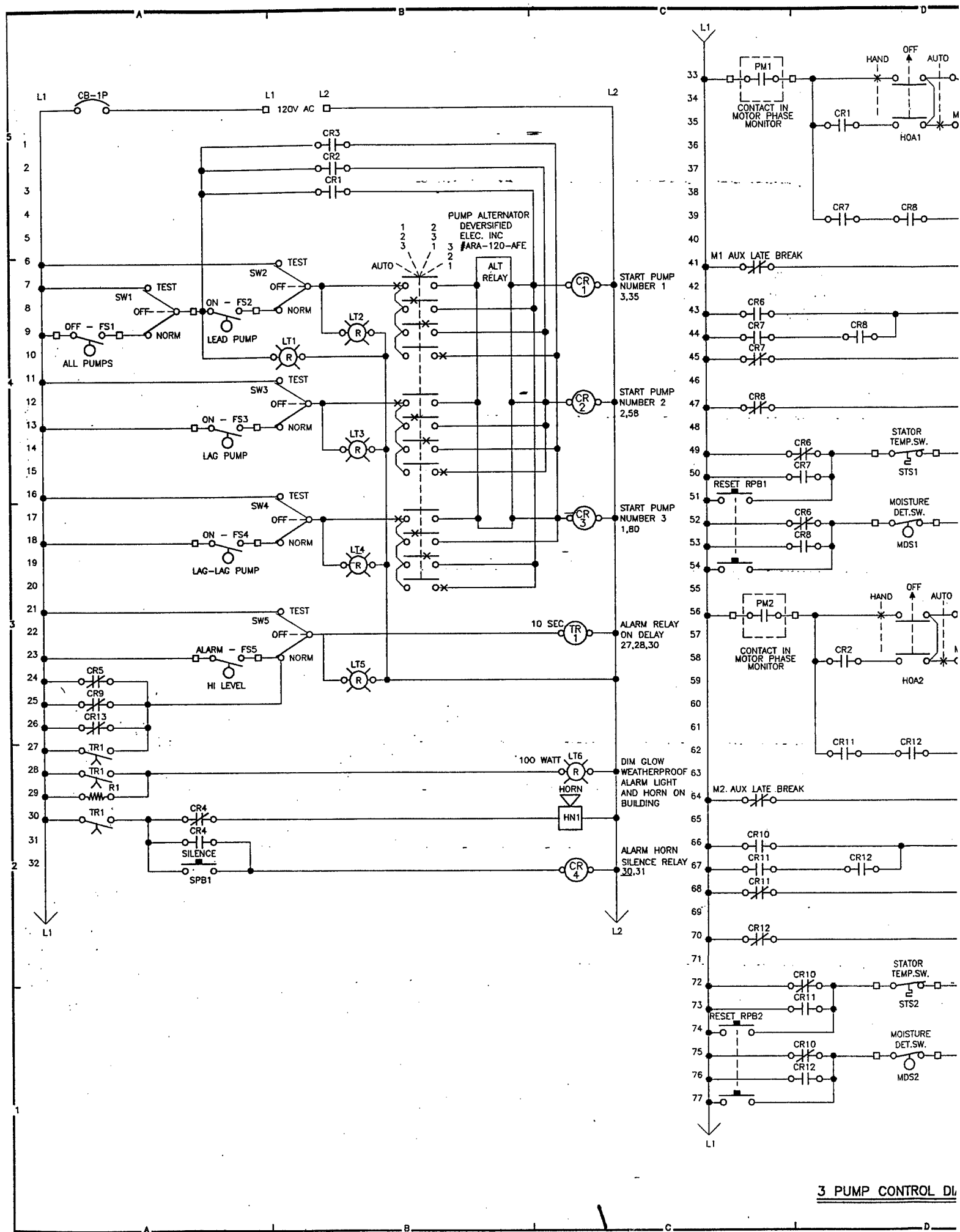
SECTION  
FORBAY AND PUMP CHAMBER

C  
05/226

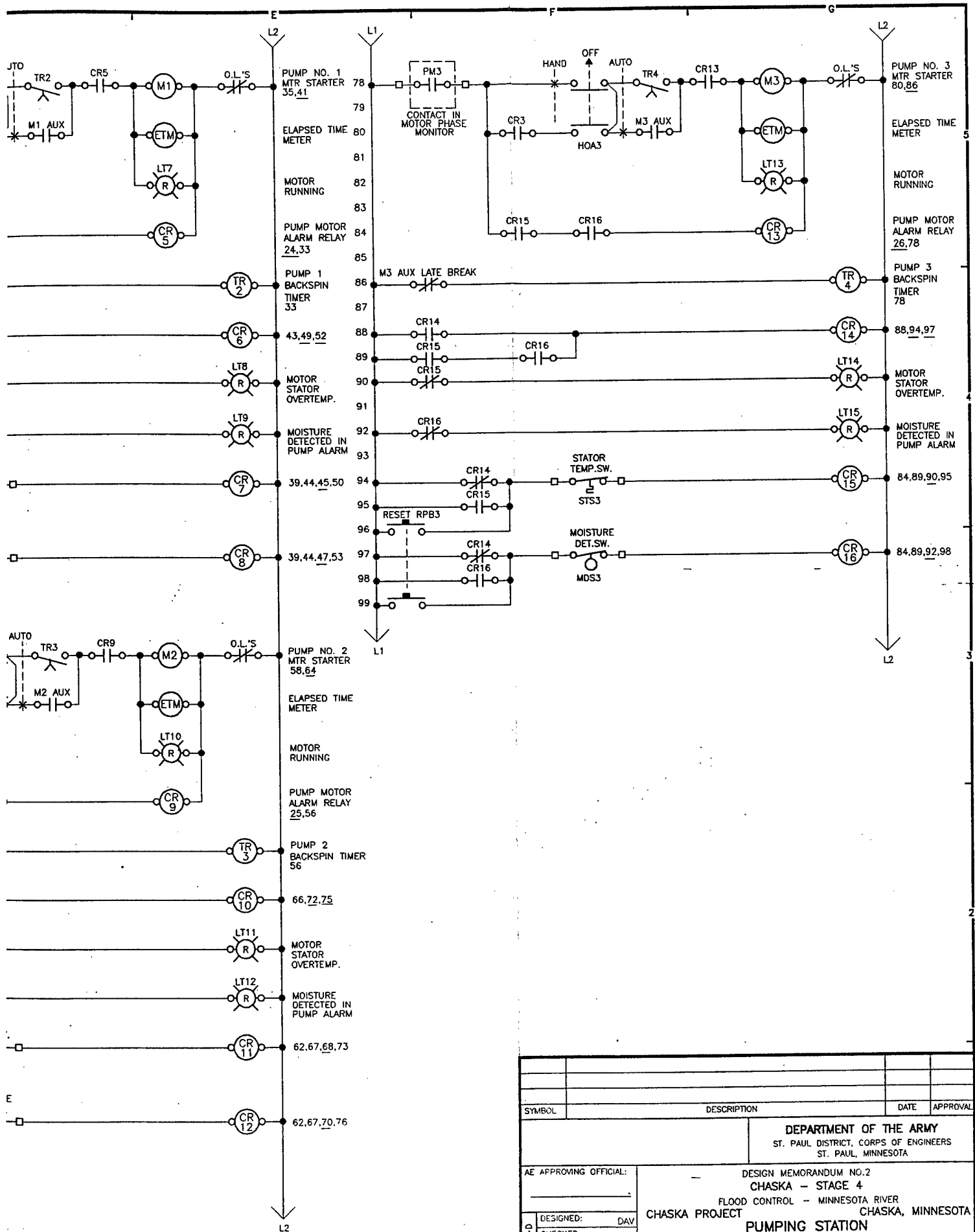
R DRAINAGE

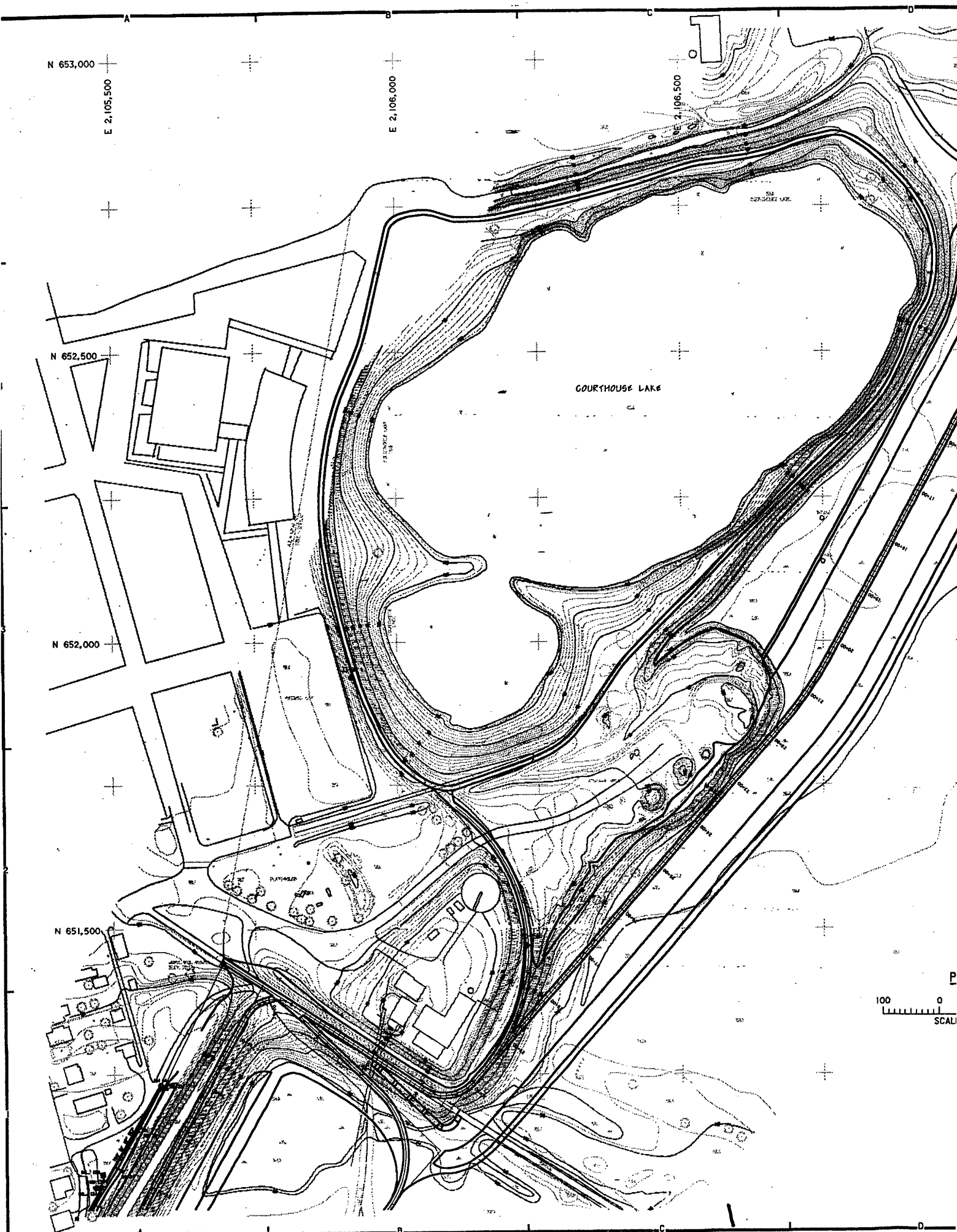
SLOPE

SYMBOL	DESCRIPTION		DATE APPROVAL
		DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA	
AE APPROVING OFFICIAL:		DESIGN MEMORANDUM NO.2 CHASKA - STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA PROJECT CHASKA, MINNESOTA	
DESIGNED: CHECKED: DRAWN:	PRK/CG	PUMPING STATION LAYOUT SECTION AND DETAILS	
	PRK/CG		
	PPC		
DESIGNED:			
CHECKED:		CAD FILE NAME: MN05R228.DWG	DRAWING NUMBER:
DATE: 03-22-91	SPEC NO: SEE DWG. 05/200	M34-CH-R-05/228	SHT 29 OF 31









N 653,000

E 2,105,500

E 2,106,000

E 2,106,500

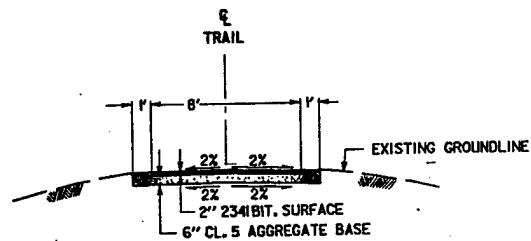
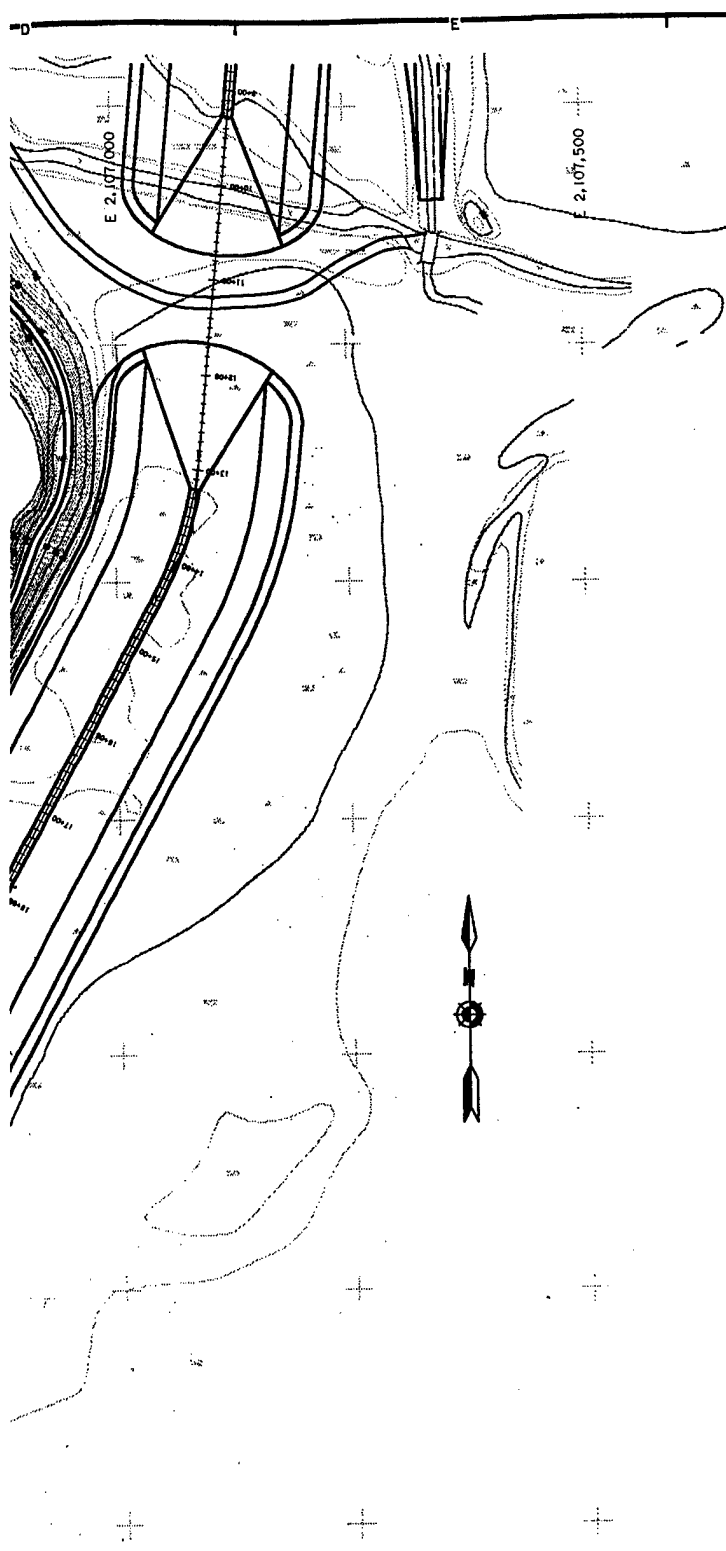
N 652,500

N 652,000

N 651,500

COURTHOUSE LAKE

100 0  
SCALE



TYPICAL SECTION

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 CHASKA STAGE 4 FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA</p>			
ED-CH	DESIGNED:	R.J.M.	<p align="center"><b>CHASKA PROJECT</b> <b>COURTHOUSE LAKE TRAIL</b> GENERAL PLAN &amp; SECTION</p>		
	CHECKED:	J.J.G.			
	DRAWN:	R.J.M.			
	DESIGNED:				
ED-CH	CHECKED:		CAD FILE NAME: MNIDPO20.DGN	DRAWING NUMBER:	SHT 31
DATE:	MAR 1991	SPEC NO:		<b>M34-CH-R-5/230</b>	OF 31

APPENDIX A

INTERIOR FLOOD CONTROL

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX A

INTERIOR FLOOD CONTROL

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MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX A

INTERIOR FLOOD CONTROL

EXISTING CONDITIONS

DESCRIPTION OF WATERSHEDS AND DRAINAGE PATTERNS FOR SECTIONS 1, 2, AND 3

A-1. The city of Chaska is located along the north floodplain of the Minnesota River generally between East and Chaska Creeks. The interior flood control basin for the entire city of Chaska consists of about 1,130 acres along Chaska Creek, East Creek and the north side of the Minnesota River. The portion of the basin contributing runoff to the stage 4 reach of levee is shown on Plate A-1 as Sections 1, 2, and 3.

A-2. Section 1, shown on Plate A-2, consists of about 36 acres which contribute runoff to the Chaska Creek channel below the proposed point of diversion. Most of the runoff from the section flows overland generally to the southeast or northwest into the former creek channel (now a designated ponding area), thence to the southwest in said channel to the newly constructed levee where this runoff is carried to the existing Chaska Creek channel through a newly installed 60-inch RCP gated gravity outlet (A). (The flood barrier and gravity outlet were installed as part of the Stage 2 construction.) The runoff from a small portion of the Section 1 watershed located east of the flood barrier and north of First Street which can not reach the existing creek channel by overland flow is carried by a newly constructed stormsewer into Section 2. This stormsewer, also part of the Stage 2 construction, consists of about 1175 feet of permanent RC pipe varying in size from 12- to 24-inches in diameter. (As indicated in paragraph A-21, this stormsewer has been temporarily extended an additional 570 feet.) Section 1 is relatively flat with elevations ranging from about 735(\*) in the northeast to about 714 in the southwest. Land use in the area is predominantly residential. During periods of high river stages, runoff will temporarily pond in the designated ponding area, pass through the newly constructed (First Street) stormsewer into Section 2, and/or pass through the 60-inch gravity outlet into Chaska Creek.

A-3. Section 2, shown on Plates A-1 and A-3, includes about 52 acres tributary to the existing gated 36-inch RCP outlet at Elm Street and the existing gated 24-inch RCP outlet just west of Highway 41, both of which pass beneath the existing dike into the Minnesota River. (The location of the outlets are shown on Plate A-3 and further described on Plate A-15.) Runoff from the 52 acres and from the First Street stormsewer outlet, located near the inside toe of the existing dike about 800 feet west of Hickory Street, flows west of Hickory Street, flows overland to the east or south to the outlets described above. In Section 2, ground level elevations vary from about 735 at the north end to about 710 at the south end. Land use in the

\*All elevations indicated in this appendix refer to National Geodetic Vertical Datum of 1929.



area is largely residential with a small amount of commercial property along Chestnut Street. During blocked gravity conditions, an existing 9,000 gallon per minute (gpm) pumping station, located at the south end of Elm Street, is used to remove runoff from Section 2. (As indicated on Plate A-3, this area has been further subdivided into six subsections for use in the design of the proposed interceptor stormsewer.)

A-4. Section 3, shown on Plates A-1 and A-3, consists of about 58 acres tributary to the existing gated 18-inch RCP outlet at Walnut Street and the existing gated 36-inch RCP outlet at Maple Street, both of which also pass under Street, both of which also pass under the existing dike into the Minnesota River. The location of the outlets are shown on Plate A-3 and further described on Plate A-15. In other respects, section 2 is similar to section 2. During blocked gravity conditions, an existing 9,000 gpm pumping station, located at the south end of Maple Street, is used to remove runoff from section 3. (As indicated on Plate A-3, this area has been further subdivided into seven subsections for use in the design of the proposed interceptor stormsewer.)

A-5. The city of Chaska does not have an extensive storm sewer system. There are a few outlets located under the existing emergency Minnesota River levee, and a newly laid sewer installed in connection with the new Highway 41 bridge across the Minnesota River. Runoff from the remainder of the city area is by overland flow. According to a representative from the city, future storm-sewers are to be designed to carry the runoff from about a 20-percent rainfall event, if there are good overflow conditions in the area; and a 10-percent event if overland flow conditions are relatively poor. The use of supplemental retention basins at interior locations is encouraged and such basins are to be designed to contain the runoff from a 1-percent event.

#### PONDING AREAS

A-6. There are currently several ponding areas inside the proposed protected area. In section 1 there is the former Chaska Creek channel adjacent to outlet A, and in section 2 and 3 there are the low areas along the existing dike. Under proposed conditions, the only designated ponding area will be located in the former Chaska Creek channel just upstream from outlet A. About 1.7 acre feet of storage is to be provided between elevations 713.5 and 718.5, which will require about 1.55 acres of ponding easements. The sides of the ponding area are to be graded, topsoiled and seeded to permit proper maintenance of the area. Also ponding markers are to be added as required. In sections 2 and 3, fill required for geotechnical reasons will virtually eliminate any storage available below the zero damage elevations. Elevation-area-storage curves for sections 1, 2, and 3 are presented on Plates A-4, A-5 and A-6, respectively.

#### DAMAGE-ELEVATION RELATIONSHIPS

A-7. Elevation-damage curves developed for Sections 2 and 3 are presented on Plate A-7, and were obtained by updating the curves presented on plates B-9 and B-10 of the revised General Design Memorandum (August 1984) to October 1990 price levels. The zero damage level for sections 2 and 3 are 711.0, and 710.5, respectively. Additional information relative to the development of the damage-elevation relationships and the location and type of damage which would occur are presented in Appendix E of the 1984 Design Memorandum.

## RIVER DISCHARGE AND STAGE DATA

A-8. Elevation-frequency curves for the Minnesota River at Chaska, obtained from Plate 4 A-4 of the Limited Reevaluation Report, dated August 1982, are presented on Plate A-8. An elevation-discharge curve for the Minnesota River at Chaska Creek (one of a family of curves developed from HEC-2 backwater profiles) is shown on Plate A-9. A stage-duration curve for the Minnesota River at Chaska Creek is presented on Plate A-10. A standard project flood (SPF) hydrograph for the Minnesota River at Chaska is presented on Plate A-11.

A-9. The United States Geological Survey (U.S.G.S.) has maintained a stream gaging station on the Minnesota River near either Carver or Jordan since 1934. The U.S.G.S. gage was originally located near Carver, Minnesota, (river mile 36.0) but in 1966 was moved to its present location near Jordan, Minnesota; (river mile 39.4) about 9.8 miles upstream from Chaska. The drainage area of the Minnesota River is about 16,200 square miles at the Jordan gage site and about 16,600 square miles at Chaska. Since this is a relatively small increase in drainage area, the discharge-frequency relations at the Jordan gage were also used for Chaska. At the selected gate closure elevation of 706.0, the discharge in the Minnesota River is about 16,000 cfs., which is equalled or exceeded about 4.3 percent of the time (or return period of once in 24 years.)

A-10. The SPF hydrograph for the Minnesota River at Chaska was obtained by increasing the flow rates obtained from the SPF hydrograph for Mankato by the ratio of their respective peak flow rates. The estimated peak SPF flow rate of 168,000 cfs at Chaska was obtained from paragraph 11, page A-3 of the revised GDM for Chaska, dated August 1984. The SPF hydrograph for the Minnesota River at Mankato was obtained from Plate A-20, "Flood Control, Minnesota River, Minnesota, Report On Probable Maximum Floods And Standard Project Floods, Minnesota River Basin, Minnesota," dated January 1971.

## RAINFALL DATA

A-11. The 1/4, 1/2, 1-, 2-, 3-, 6-, 12-, 24-, 48-, and 96-hour point rainfall depths for the 100-, 40-, 20-, 10-, 4-, 2-, and 1-percent all-year theoretical rainfall events in the Chaska area were developed from National Weather Service (U.S. Weather Bureau) publications HYDRO-35, TP-40, and TP-49 and are presented on Plates A-12 and A-13 and in Table A-1. The incremental rainfall amounts at 10-minute intervals are presented in Table A-2. The incremental rainfall amounts based on a 4-2-1-3 distribution are presented in Table A-3. The point rainfall amounts for the standard project storm, developed in accordance with criteria presented in EM 1110-2-1411, is also shown in Tables A-3 through A-13 and on Plates A-12 and A-13.

A-12. Historical rainfall data were obtained from the U. S. Department of Commerce publication "Climatological Data." Daily rainfall records for Chaska are available from August 1911 through 1988. Since there is no recording gage located in the Chaska area, estimated hourly rainfall amounts have been obtained by use of the hourly amounts from nearby recording gages and proportioning these recorded hourly amounts equal to the recorded daily rainfall amounts at Chaska. The recording gages used are located at either the Minneapolis-St. Paul international airport (located about 22 miles east-northeast of Chaska), LeSueur, Minnesota (located about 28 miles to the south west), Northfield, Minnesota (located about 32 miles to the southeast), or at

Hutchinson, Minnesota (located about 40 miles to the west-northwest). The estimated hourly rainfall distribution for rainfall events at Chaska with a 48 hour total of 3 inches or more are presented in Table A-4. The estimated hourly amounts for all events of 0.4 inches or more, which occurred when the Minnesota River equalled or exceeded elevation 706.0, are presented in Table A-5.

#### RUNOFF HYDROGRAPHS

A-13. Runoff hydrographs for each of the interior watersheds were developed based on criteria presented in Soil Conservation Service (SCS) Technical Release 55 (TR55), dated June 1986, titled: "Urban Hydrology for Small Watersheds," and using the SCS unit hydrograph method in the HEC-1 computer program. Key parameters used in the computer program are presented in Table A-6. The 10-minute and 60-minute unit-hydrographs obtained for each of the watersheds are presented in Table A-7. Runoff hydrographs for the 100-, 40-, 20-, 10-, 4-, 2-, and 1-percent and standard project storms for each of the 13 sub-watersheds of sections 2 and 3 and for the inflow from section 1 are presented in Tables A-8 through A-14 and A-16, respectively. Runoff hydrographs for the most intense rainfall events which occurred July 27, 1949; July 21, 1951, June 21, 1983, and July 21, 1987 are presented in Table A-15. Runoff hydrographs for historical events which occurred during high Minnesota River stages are presented in Table A-17.

A-14. The size of each sub-watershed and estimated ground slopes (presented in Table A-6) used to obtain time of concentrations were obtained from U.S.G.S. quad sheets. Time of concentrations were obtained using Worksheet 3 of TR55. The Manning's n value used assumes a dense grass ground cover. The two-year, 24-hour rainfall amount for Chaska was obtained from Figure III-1b, page III-8 of National Weather Service publication "Hydro - 35." Lag time was assumed to be equal to 60 percent of the time of concentration as defined on page 15-6, SCS National Engineering Handbook, Section 4, "Hydrology." The ratios of imperviousness used are the same as used in earlier reports and are indicated in Table A-6. The SCS curve numbers were obtained based on a soil group B and a antecedent moisture condition II.

#### SEEPAGE

A-15. The estimated seepage rates per foot of head used in the design of the proposed pumping station are 187.5 gpm in Section 2 (62.5 gpm between stations 55+00 and 59+00 and 125 gpm between stations 59+00 and 91+75) and 635 gpm in Section 3 (between stations 33+50 and 55+00). Seepage in Section 1 is considered to be insignificant. Seepage rates are further discussed in the "Seepage and Uplift Analysis" section of Appendix C.

#### RECOMMENDED PLAN

##### GENERAL

A-16. The recommended interior flood control plan will consist of two gated gravity outlets, including preformed scour holes; about 3,740 feet of intercepting storm sewer, including 16 street inlet structures located along the sewer line at each street intersection; and a new 18,000 gpm pumping station. The four existing RCP gravity outlets, and two 9,000 gpm pumping stations are to be removed. The required size, type, length, invert

elevations and hydraulic gradients for the proposed gravity outlets and storm-water interceptor sewers are presented in Tables A-18 and A-19 and on Plates A-21, A-22 and A-24. The required size, and rim elevation of the proposed grated street inlets are presented in Table A-20. The required facilities are further defined in the following paragraphs.

#### DEPARTURES FROM GENERAL DESIGN MEMORANDUM, SUPPLEMENT NO. 1

A-17. Based on revised hydrology for Sections 2 and 3, the recommended size off of the gravity outlet in section 2 was decreased from a 90-inch RCP to a 72-inch RCP, and the recommended size of gravity outlet for section 3 was decreased from a 84-inch RCP to a 66-inch RCP. Revisions have also been made to the pipe sizes for the interceptor sewers in sections 2 and 3. A new stormsewer line from Section 1, constructed under Stage 2, has resulted in the required extension of the proposed interceptor sewer to the west. Also the design of the interceptor is now based on average antecedent moisture conditions, and to satisfactorily contain the runoff from a standard project storm. Based on the revised seepage quantities, the capacity of the proposed pumping station has been reduced from 23,000 gpm to 18,000 gpm.

#### GRAVITY OUTLETS

A-18. Outlet B, as shown on Plate A-21, is to be located beneath the levee in Section 2 just upstream of the Highway 41 bridge. The outlet is to consist of a 72-inch and twin 48-inch RCP with gatewell, sluice gate, and preformed scour hole. The 72-inch pipe will extend from the intercepting stormsewer downstream about 90 feet to the proposed concrete gatewell with sluice gate. The twin 48-inch pipe will extend from the gatewell downstream about 124 feet to the Minnesota River, where a preformed scour hole will be constructed. The 72-inch pipe will be layed with an inlet invert elevation of 693.5 and an outlet invert elevation of 693.0. The 48-inch pipes are to be layed with an invert elevation of 683.0. The preformed scour hole, as shown on Plate A-23, is to be constructed with a 12' x 16' base at elevation of 679.0 with 1 on 3 side slopes.

A-19. Outlet C, as shown on Plate A-22, is to be located beneath the levee in Section 3 near the end of Oak Street. The outlet is to consist of a 66-inch and twin 48-inch RCP with gatewell, sluice gate, and preformed scour hole. The 66-inch pipe will extend from the intercepting stormsewer downstream about 93 feet to the proposed concrete gatewell with sluice gate. The twin 48-inch pipe will extend from the gatewell downstream about 113 feet to the Minnesota River, where a preformed scour hole will be constructed. The 66-inch pipe will be layed with the same invert elevations as Outlet B. The 48-inch pipes are to be layed with an invert elevation of 683.0, and the preformed scour hole is to be constructed with the same elevations and dimensions used for Outlet B. Elevation-discharge curves for Outlets B and C are presented on Plates A-16.

#### RIPRAP REQUIRMENTS

A-20. A 12-inch layer of riprap is required over the proposed preformed scour holes and about 20 feet in each direction from the scour holes and to each side and above the two proposed gravity outlets. Based on a stone specific weight of 165 lbs./cu. ft. and a 12-inch layer, the required stone graduation is as follows:

Percent Lighter By Weight	Weight Maximum	Limits Minimum
100	86	35
50	26	17
15	13	5

#### STORMSEWER FROM SECTION 1

A-21. Most runoff from Section 1 will enter this sewer to the north and west of First Street at inlets 12 and 12d. Inlet 12 consists of a Neenah grate type R-2561 with a rim elevation of 717.3. Inlet 12d consists of a Neenah grate type R-3067v with a rim elevation of 716.0. Runoff entering these two structures is carried by stormsewer to a manhole 12c where it discharges into the same sewer. The sewer connecting inlet 12 with manhole 12c consists of 243 feet of 15-inch RCP. The sewer connecting inlet 12d with manhole 12c consists of 44 feet of 12-inch RCP and 200 feet of 18-inch RCP. From manhole 12c to the proposed Inlet 1 will consist of about 622 feet of 24-inch RCP with an outlet invert elevation of about 701.37. An elevation-discharge curve for this sewerage system is presented on Plate A-14.

#### DESIGNATED PONDING AREAS

A-22. There will be no designated ponding areas in sections 2 and 3.

#### INTERCEPTOR STORM SEWER

A-23. An intercepting storm sewer, about 3,740 feet long, will be required along the inside toe of the Minnesota River levee and berm from the permanent outlet of the stage 2 stormsewer located southwest of Spruce Street in Section 2 to the east of Maple Street near the downstream end of Section 3 to intercept local runoff and seepage. The required pipe sizes, lengths, and invert elevations for the proposed intercepting stormsewer are presented in Table A-18 and shown on Plate A-24.

#### PUMPING STATION

A-24. An 18,000 gpm pumping station, equipped with three 6,000 gpm pumps, is to be located near the end of Oak Street adjacent to Outlet C. The pumping station will discharge over the top of the levee into the gatewell of Outlet C. System head-capacity curves for the recommended pump are presented on Plate A-25. Criteria used in the design of the pumping station is presented in paragraphs A-38 through A-45.

#### PLAN OF OPERATION

A-25. During low river-gravity flow conditions, the sluice gates in gatewells B and C will be open. Runoff from section 1 will flow into the portion of Chaska Creek below the point of diversion, down the creek bed and finally discharge through Outlet A into the Chaska Creek diversion channel, and/or through the interior stormsewer into Section 2. Runoff from Sections 2 and 3 will discharge by overland flow to the proposed levee, intercepted by the proposed inlet structures, and thence carried to Outlets, B and C, respectively, through the proposed intercepting stormsewers and thence into the Minnesota River.

A-26. During flood periods when the Minnesota River at the Highway 41 bridge equals or exceeds elevation 706.0, the sluice gates in gatewells B and C will be closed. The gates at the entrance to the pumping station will be opened and the pumps activated. When the river exceeds elevation 713.5, runoff from section 1 will pond adjacent to outlet A, and flow through the interior stormsewer into the Section 2 interceptor. (It will not be necessary to close the sluice gate in gateway A unless the flap gate fails.) The proposed pumping station will be equipped for both automatic and manual control operations. The normal operating range of the pumps in the proposed pumping station will be between elevations 698.0 and 702.5. The pumps on levels are 701.5, 702.0, and 702.5 and all pumps will turn off at elevation 698.0.

## PROJECT JUSTIFICATION

### PERFORMANCE OF PROPOSED STORMWATER SEWERAGE SYSTEM AND GRAVITY OUTLETS

A-27. Since the minimum ground level landward of the proposed levee will be raised to only about one to two feet below the existing standard project storm (SPS) level, and there is no significant storage volume within this reach; the proposed stormwater sewerage system has been designed to contain the runoff from a SPS. In comparing the estimated peak runoff from a SPS, indicated in Table A-16, with the estimated peak runoff from the most intense historical rainfall events, presented in Table A-15; it is evident that the design SPS event is by far more severe than any historical event which has occurred to date. An intercepting sewer plan based on a one-percent rainfall event would have resulted in SPS levels far higher than that which would have occurred under existing conditions. In addition to a hydraulic gradient for the one-percent and SPS event, Table A-18 also includes a hydraulic gradient for the runoff from a 10- and 20-percent event, because the City of Chaska plans to install a stormwater sewerage system designed to contain the runoff from these events. The estimated maximum interior pond level and resulting flood damage in sections 2 and 3 resulting from a 1-percent and SPS with and without the project are presented in Table A-21. The maximum pond levels are taken from Table A-18. Damages were obtained from Plate A-7. Elevation-discharge curves for Outlets B and C based on existing and proposed conditions are presented on Plate A-15 and Plate A-16, respectively.

A twin 48-inch pipe is recommended downstream of each gateway to permit the satisfactory outflow during a SPS event, a crown elevation below the estimated ice line and an outlet invert elevation above the bottom of the river channel. The low water elevation for the Minnesota River at Chaska is about 688.0, thus the maximum allowable pipe crown elevation to avoid the formation of ice within the pipe is assumed to be about 687.0. A preformed scour hole is required at the downstream end of these pipes to prevent damage from erosion and scour at the pipe outlets and to possibly prevent the formation of sedimentation deposits within the pipes.

### SELECTION OF GATE CLOSURE ELEVATION

A-28. In Sections 2 and 3, the selected gate closure level is 706.0 to prevent the backup of runoff into the proposed relief wells. At this level, the flow in the Minnesota River is about 16,000 cfs, which is equalled or exceeded about 4.6 percent of the time.

## JUSTIFICATION OF PUMPING STATION

A-29. The recommended 18,000 gpm pumping station is based on the estimated peak seepage rate which would occur during a standard project flood (SPF) on the Minnesota River, the capacity required based on a period of record - economic analysis, and the existing pumping capacity in Chaska. The estimated peak seepage rate which would occur during a SPF on the Minnesota River, as indicated in Table A-22, would be about 19,200 gpm based on a constant interior pond level of 706.0; however the estimated peak seepage rate expected during a SPF is about 18,000 gpm with an interior pond level of about 707.4. This level is only about 0.4 feet above the maximum allowable interior pond level required for the satisfactory operation of the proposed relief well system and can be expected to occur only during an extremely rare and short occasion. Based on a period of record - economic analysis, the most economical size of pumping station is about 17,800 gpm. There are currently two 9,000 gpm pumping stations located along the levee at Elm and Maple Streets. However with the required increase in pumping head, these existing stations will not be able to satisfactorily remove the interior runoff at this rate.

A-30. An economic-period of record analysis was used because of the potential for the occurrence of a significant amount of seepage with high river stages. The design of separate pumping stations for Sections 2 and 3 was found in earlier studies to be more costly than a single combined station and, therefore, was not considered during the current study. The location of the proposed pumping station was first considered at the end of Elm Street, however, its location has been moved downstream adjacent to Outlet C, to reduce project costs and because a good share of the pumped runoff will be from seepage through the levee and occur downstream of Highway 41.

A-31. Maximum pond levels which would have occurred during past periods of blocked gravity drainage with and without pumping are presented in Table A-23. Based on hourly rainfall records since 1949, there have been only two events when the Minnesota River at Chaska was above the selected gate closure level of 706.0 and there would have been an interior runoff rate greater than 18,000 gpm. During May 7-8, 1965 with the Minnesota River at about elevation 706.1 and the installation of an 18,000 gpm pumping station, the 2.1 inch recorded rainfall would have resulted in a peak runoff rate of about 26,303 gpm and resulted in the temporary storage of about 2.1 acre feet of runoff. During July 10-11, 1984 with the Minnesota River at about elevation 706.3 and the proposed pumping station in place, the 2.64 inch recorded rainfall would have resulted in a peak runoff of about 23,580 gpm and resulted in the temporary storage of about 2.1 acre feet of runoff. As indicated on Plates A-5 and A-6, the available storage below the zero damage level of 710.5 is about 1.2 acre feet in Section 2 and about 3.3 acre feet in Section 3, or about 4.5 acre feet in the combined areas. Also since the river level during these events was only about 0.3 feet or less above the selected gate closure level, the gates could have been temporarily opened to remove the excess runoff. (According to a representative from the City of Chaska, the two existing pumping stations were installed about 1951 and the city does not maintain detailed records on pumping operations.)

A-32. Based on the 53 years of record presented in Table A-23, there would have been 51 periods of blocked gravity drainage, and 28 years during which a flood period would have occurred. During this same period there would have

been about 819 days of blocked gravity drainage and a total of about 77.98 inches of precipitation. Assuming an average seepage rate of 812.5 gpm per foot of head, a constant interior pond level of 706.0, instantaneous seepage, and the Minnesota River rises to the peak and recedes linearly, the estimated seepage which would have occurred during the 53 year period is about 8,430 acre feet. Assuming 82 percent runoff, the estimated precipitation runoff during the period is about 586 acre feet. Based on a flood period occurring during 28 of the 53 years of record, the average flood frequency is about once every 2 years. The average duration of flooding is about 819 days during 51 events, or about 16 days. The total volume pumped would have been 9.016 acre feet. Distributed evenly during the 28 years of blocked gravity drainage, the 51 flood events, or the 53 years of record; this volume becomes about 322, 177, and 170 acre feet, respectively. Assuming only one of the 6,000-gpm pumps is operating, these volumes become about 292, 160, and 154 hours of pumping, respectively.

A-33. As indicated in Table A-18, the recommended highest pump-on level is about 702.50 feet. If this level is raised and the design 18,000 gpm discharge would occur, the hydraulic gradient in the intercepting stormsewer would exceed elevation 705.53. To permit the satisfactory operation of the proposed relief well system, it is recommended that the hydraulic gradient referably not exceed elevation 706.0 and definitely not exceed elevation 707.0.

#### DESIGN CRITERIA

##### DESIGN OF GRAVITY DESIGN FEATURES

A-34. The design of the interceptor sewers and gravity outlets is based on criteria presented in TM 5-820-4 and on the peak inflow from an SPS event. The design of the proposed intercepting sewers are based on the allowable head between the outlet invert elevation at Outlets B and C and the estimated SPS interior pond levels under existing conditions; 710.9 for the area upstream of Highway 41 (Section 2), and 712.5 for the area downstream of Highway 41 (Section 3). All gravity outlets, and permanent interceptor sewers are to be constructed of reinforced concrete pipe. (The temporary sewer segment constructed as part of stage 2 is to be PVC pipe.) The Manning's roughness coefficient for concrete and PVC pipe is assumed to be 0.014 and the entrance loss coefficient is assumed to be 0.5 for the gravity outlets and 0.2 for the interceptor sewers. The intercepting stormsewers are designed with matching crowns and on a constant slope of 0.002 feet/foot. (Elevation-head-discharge curves for outlets B and C for existing and proposed conditions are presented on Plates A-15 and A-16, respectively.) The hydraulic design of inlet structures, presented in Table A-20, is based on the criteria presented in TM 5-820-4, assuming 50 percent blockage, a rim elevation near the existing ground elevation, and a maximum allowable head equal to the difference between the selected rim elevation and the estimated SPS pond level under existing conditions.

A-35. The outlet invert elevations are set at 683.0 to eliminate the possibility of ice formation inside the pipe during the winter and/or spring months and subsequent loss of discharge capacity. As indicated on Plate A-10, the estimated mean average Minnesota River stage (i.e. a flow equalled or exceeded 50 percent of the time) is 691.7.

A-36. In Table A-18, two hydraulic gradients are provided to represent the



estimated runoff during blocked conditions. The discharge rates representing seepage only were obtained as indicated in Table A-19, assuming the Minnesota River at elevation 729.58 and the accumulation of seepage from the extremities of the line of protection to the proposed pumping station located at Oak Street. The discharge rates representing the gravity (interior rainfall runoff) condition were obtained assuming an accumulative peak inflow rate of 40.1 cfs (18,000 gpm) at the pumping station with incremental inflow rates at each of the 13 proposed inlets equal to the ratio of the accumulative peak unit hydrograph rate for the given inlet to the total of the combined peak unit hydrograph rate from all inlets, times 40.1.

#### RIPRAP DESIGN

A-37. The design of the riprap cover required over and adjacent to the preformed scour holes and adjacent to the gravity outlets is based on criteria presented in HDC, sheet 7121 and ETL 1110-2-120, assuming a tailwater depth of 5 feet, a 48-inch outlet pipe, and a design discharge rate of 120 cfs at Outlet B and 127 cfs at Outlet C. The required minimum allowable 50-percent stone diameter is 0.164 feet, or about 2.0 inches. The minimum allowable 50-percent stone weight is 0.387 pounds.

#### DESIGN OF PUMPING STATION

A-38. The required capacity of the proposed pumping station was determined based on the larger required capacity obtained using an economic-period of record analysis, the estimated peak seepage rate during a SPF, and the existing pumping capacity available.

A-39. The estimated peak seepage rate during a SPF, as indicated in Table A-22, is estimated to be about 19,171 gpm, assuming seepage will occur at the rate of 812.5 gpm per foot of head and the interior pond level remains at elevation 706.0.

A-40. An economic-period of record analysis was performed based on the 53 years of record from 1 October 1934 through 30 September 1987; a selected gate closure level of 706.0; a combined seepage rate in Sections 2 and 3 of 812.5 gpm per foot of head; and selected station capacities of 5,000, 10,000, 15,000, and 20,000 gpm. Since there is only negligible ponding available at the lower levels, pumps are assumed to start and stop simultaneously at the selected gate closure level. The station design is based on criteria presented in EM 1110-2-3102 and EM 1110-2-3105.

A-41. The need for a pumping station during the 53 year period of record based on the selected pumping rates is summarized in Table A-23. The periods of blocked gravity drainage indicated in the table include all periods from 1934 through 1987 during which the Minnesota River stage at the Highway 41 Highway 41 bridge equalled or exceeded the proposed gate closure elevation of 706.0. The maximum river stages indicated are the maximum stages recorded during each period of blocked gravity drainage. The precipitation indicated in Table A-23 is the sum of all rainfall and/or snowmelt which occurred during the selected period based on the recorded daily amounts at Chaska. The maximum pond elevations reached during each period of blocked gravity drainage, with and without pumping, were estimated by routing all inflow (seepage and runoff) through the ponding area, and starting and stopping pumping operations at the selected gate closure level. To determine the most

critical condition, routings were performed first on a daily basis, then analyzed on an hourly basis using the runoff hydrographs presented in Table A-17. The gates on the gravity outlets are assumed to remain closed throughout the flood period.

A-42. Pond elevation-frequency curves developed for each selected pumping rate are presented on Plate A-17. A curve was developed for each pumping rate by rearranging the pond levels in descending order, ranking the pond levels from high to low, and assigning a plotting position for each pond level based on the Weibull statistical method presented in Bulletin No.17B.

A-43. Damage-frequency curves were then developed for each pumping rate and are shown on Plate A-18. These curves were obtained by converting the elevations indicated on Plate A-17 into damages based on the elevation-damage curves provided on Plate A-7, and then plotting a damage-frequency curve for each condition. The elevation-damage-frequency relations for each event are presented in Table A-24. Average annual damages were then determined by planimetering the area under each curve, and multiplying the resulting area in square inches times the average annual damages per square inch. Average annual benefits is equal to the difference between the average annual damages without pumping less the average annual damages for the given pumping rate.

A-44. The estimated first cost for constructing a new pumping station, is based on information received from the Cost Engineering Branch. The method and assumptions used to obtain estimated average annual pumping costs are presented in Table A-25. A pumping station cost-capacity curve is presented on Plate A-19.

A-45. The required size of pumping station was then obtained based on the capacity required to obtain maximum net benefits. This rate was obtained by plotting average annual pumping costs against average annual benefits, drawing the curve of best fit, and then drawing a straight line on a \$1 benefit to \$1 cost slope tangent to the curve. The point of intersection is the point of maximum net benefits. The average annual cost - average annual benefit curve for this study is presented on Plate A-20.

#### ALTERNATE PLANS

A-46. Four alternate intercepting sewer designs were considered. All plans assume the same pipe lengths, inlet locations, and design criteria, however, the proposed pipe elevations, and sizes vary with each plan. Plan A assumes Outlet B will be located at the end of Elm Street, Outlet C will be located near the end of Ash Street, and the inlet invert elevations to each outlet will be at 698.0. Plan B assumes Outlet B will be located at the end of Pine Street, Outlet C will remain near the end of Ash Street, and the inlet invert elevations to each outlet will remain at 698.0. Plan C assumes Outlet B at Pine Street, Outlet C moved upstream to the river end of Oak Street, and the outlet inlet invert elevations lowered to 693.5. Plan D is the recommended plan. Plans A and B were eliminated because of the larger pipe sizes required with the selected high outlet pipe invert elevations. Also with Plan A, Outlet B would discharge into Chaska Creek, where the existing channel is much narrower, the channel bottom is much higher and the tailwater conditions are more variable and may rise concurrently with outflow from the interior area. (Stages on the Minnesota River are much lower and will be relatively stable

during periods of interior runoff.) Plan C was eliminated, because the outlet runoff.) Plan C was eliminated, because the outlet pipe at Pine Street would be required to pass beneath an existing parking lot located riverward of the levee and subsequently require a relatively long segment of twin 48-inch outlet pipe.

A-47. Several alternate plans were considered for providing erosion and scour protection at the river end of Outlets B and C. One alternate was to extend the 72- and 66-inch pipes from the gatewell to the river with an invert elevation of 693.0, construct a concrete headwall at the downstream end, and lay a bed of riprap along the river bank to the bottom of the river. This plan was eliminated, because there is no assurances that even a heavy bed of riprap could withstand the forces of the pipe outflow. (The estimated discharge velocity at the bottom of the river bank would be about 30 feet per second.)

A-48. Another alternate outlet plan was to extend both Outlets B and C to the Minnesota River and construct a St. Anthony Falls drop structure at the downstream end to dissipate the outflow energy. The required drop structure would require a drop of about 15 feet, a length of about 56 feet, a width of about 10 to 15 feet, with several baffle blocks and an end sill. This alternative was also eliminated, because of excessive cost, the required projection into the river, and/or its cutting into the levee cross-section.

#### REFERENCES

A-49. The following references were used in the development of the interior flood control plan:

a. EM 1110-2-1411, "Standard Project Flood Determination," (Civil Works Engineer Bulletin No. 52-8, March 1952).

b. EM 1110-2-1413, "Hydrologic Analysis of Interior Areas," January 1987.

c. EM 1110-2-1601, "Hydraulic Design of Flood Control Channels."

d. EM 1110-2-1602, "Hydraulic Design of Reservoir Outlet Works."

e. EM 1110-2-3101, "Pumping Stations-Local Cooperation and General Considerations."

f. EM 1110-2-3102, "General Principles of Pumping Station Design and Layout."

g. EM 1110-2-3105, "General Principles of Pumping Station Design and Layout."

h. ETL 1110-2-120, "Engineering And Design, Additional Guidance For Riprap Channel Protection."

i. TM 5-820-4, "Drainage for Areas Other Than Airfields."

j. Hydraulic Design Criteria, Sheet 712-1, "Stone Stability, Velocity Vs. Stone Diameter," Revised 9-70.

k. "Water Resources Data for Minnesota," U.S. Department of the Interior, Geological Survey.

1. National Weather Service HYDRO-35, "Five- to 60-Minute Precipitation Frequency For The Eastern And Central United States," June 1977.

m. National Weather Service Technical Report No. 40, "Rainfall Frequency Frequency Atlas of the United States," May 1961.

n. National Weather Service Technical Report No. 49, "Two- to Ten-day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States," 1964.

o. Soil Conservation Service Technical Release No. 55, "Urban Hydrology for Small Watersheds," June 1986.

p. SCS National Engineering Handbook, Section 4, Soil Conservation Service, U.S. Department of Agriculture, August 1972.

q. "Climatological Data," National Oceanic and Atmospheric Administration, Environmental Data Service, U.S. Department of Commerce.

r. "Minnesota River At Chaska, Minnesota, Limited Reevaluation Report," August 1982.

s. "Minnesota River At Chaska, Minnesota, Flood Control Project, General Design Memorandum," Revised August 1984.

t. "Minnesota River At Chaska, Minnesota, Flood Control Project, Design Memorandum No. 1, Chaska Creek," December 1984.

u. "Minnesota River At Chaska, Minnesota, Flood Control Project, General Design Memorandum, Supplement No. 1," April 1986.

v. "Flood Control, Minnesota River, Minnesota, Report On Portable Maximum Floods And Standard Project Floods, Minnesota River Basin, Minnesota," January 1971.

w. "Flood Control, Minnesota River, Minnesota, Mankato-North Mankato-LeHllier, Design Memorandum No. 7, Mankato Stage 3C," September 1981.

x. "Design Memorandum And Environmental Assessment, St. Paul Flood Control Project, Mississippi River at St. Paul, Minnesota," March 1990.

y. "Flood Control, Middle River At Argyle, Minnesota, Stage 2," Plans And Specifications.

z. "Hydraulic Charts for the Selection of Highway Culverts," Hydraulic Engineering Circular No. 5, U.S. Department of Transportation, Federal Highway Administration, April 1977.

aa. "Guidelines for Determining Flood Flow Frequencies," Bulletin No. 17B of the Hydrology Committee, March 1982, U.S. Water Resources Council.

bb. "Erosion Control Measures At Storm Sewer And Culvert Outlets," by John L. Grace, Jr., Waterways Experiment Station, Vicksburg, Mississippi.

cc. "Straight Drop Spillway Stilling Basin," by Charles A. Donnelly and

Fred W. Blaisdell, Hydraulic Engineers, USDA, ARS, Technical Paper No. 15, Series B, University Of Minnesota St. Anthony Falls Hydraulic Laboratory, November 1954.

dd. "Flow of Flood Water Over Railway and Highway Embankments," by David L. Yarnell and Floyd A. Nagler, published in "Public Works," April 1930.

TABLE A-1

## ACCUMULATED 96-HOUR THEORETICAL RAINFALL AMOUNTS

Rainfall Duration In Hours	Rainfall Frequency In Percent					
	100	40	20	10	4	2
0.5	0.90	1.23	1.44	1.67	1.89	2.16
1.0	1.14	1.51	1.75	2.06	2.32	2.63
1.5	1.25	1.68	1.94	2.29	2.58	2.95
2.0	1.33	1.81	2.09	2.47	2.79	3.16
2.5	1.40	1.90	2.21	2.59	2.94	3.32
3.0	1.46	1.98	2.30	2.71	3.06	3.47
3.5	1.51	2.05	2.38	2.81	3.18	3.59
4.0	1.55	2.11	2.43	2.89	3.28	3.69
4.5	1.59	2.17	2.49	2.96	3.37	3.79
5.0	1.63	2.23	2.55	3.02	3.45	3.87
5.5	1.67	2.28	2.60	3.08	3.51	3.94
6.0	1.69	2.33	2.65	3.14	3.57	4.01
12.0	1.85	2.60	3.00	3.50	4.10	4.60
18.0	2.00	2.85	3.30	3.80	4.50	5.10
24.0	2.15	2.95	3.50	4.00	4.75	5.40
48.0	2.60	3.50	4.10	4.60	5.60	6.40
72.0	2.85	3.80	4.50	5.10	6.15	7.00
96.0	3.15	4.15	4.85	5.55	6.60	7.45

TABLE A-2

## HOURLY INCREMENTAL RAINFALL AMOUNTS

Rainfall Duration In Hours	Rainfall Frequency In Percent						Duration In Hours	SPS
	100	40	20	10	4	2		
0.167	0.01	0.02	0.02	0.02	0.02	0.02	0.167	0.16
0.333	0.01	0.02	0.02	0.02	0.02	0.02	0.333	0.16
0.500	0.01	0.02	0.02	0.02	0.02	0.02	0.500	0.16
0.667	0.01	0.02	0.02	0.02	0.02	0.02	0.667	0.16
0.833	0.01	0.02	0.02	0.02	0.02	0.03	0.833	0.16
1.000	0.01	0.02	0.02	0.02	0.02	0.03	1.000	0.16
1.167	0.01	0.02	0.02	0.02	0.02	0.03	1.167	0.16
1.333	0.01	0.02	0.02	0.02	0.03	0.03	1.333	0.17
1.500	0.01	0.02	0.02	0.02	0.03	0.03	1.500	0.17
1.667	0.01	0.02	0.02	0.02	0.03	0.03	1.667	0.18
1.833	0.01	0.02	0.02	0.02	0.03	0.03	1.833	0.18
2.000	0.01	0.02	0.02	0.03	0.03	0.03	2.000	0.19
2.167	0.01	0.02	0.02	0.03	0.03	0.03	2.167	0.19
2.333	0.02	0.02	0.02	0.03	0.03	0.03	2.333	0.19
2.500	0.02	0.02	0.02	0.03	0.04	0.04	2.500	0.19
2.667	0.02	0.02	0.02	0.03	0.04	0.04	2.667	0.19
2.833	0.02	0.02	0.03	0.03	0.04	0.04	2.833	0.19
3.000	0.02	0.02	0.03	0.03	0.04	0.04	3.000	0.20
3.167	0.02	0.03	0.03	0.04	0.04	0.05	3.167	0.21
3.333	0.02	0.03	0.03	0.04	0.04	0.05	3.333	0.21
3.500	0.02	0.03	0.03	0.04	0.04	0.05	3.500	0.22
3.667	0.02	0.03	0.04	0.04	0.05	0.05	3.667	0.23
3.833	0.02	0.03	0.04	0.04	0.05	0.05	3.833	0.24
4.000	0.02	0.03	0.04	0.04	0.05	0.06	4.000	0.24
4.167	0.03	0.04	0.05	0.06	0.07	0.07	4.167	0.24
4.333	0.03	0.04	0.05	0.06	0.07	0.07	4.333	0.24
4.500	0.03	0.05	0.05	0.06	0.07	0.07	4.500	0.24
4.667	0.03	0.05	0.06	0.07	0.08	0.08	4.667	0.24
4.833	0.04	0.06	0.06	0.08	0.09	0.09	4.833	0.24
5.000	0.04	0.06	0.07	0.08	0.09	0.10	5.000	0.24
5.167	0.07	0.07	0.08	0.10	0.10	0.13	5.167	0.25
5.333	0.08	0.09	0.10	0.13	0.14	0.17	5.333	0.25
5.500	0.09	0.11	0.13	0.16	0.19	0.23	5.500	0.26
5.667	0.20	0.26	0.30	0.36	0.41	0.47	5.667	0.61
5.833	0.30	0.41	0.47	0.56	0.63	0.71	5.833	0.96
6.000	0.40	0.55	0.66	0.75	0.85	0.98	6.000	1.33

TABLE A-3

## INCREMENTAL RAINFALL IN 4-2-1-3 DISTRIBUTION

Time In Hours	Rainfall Frequency In Percent								SPS
	100	40	20	10	4	2	1	SPS	
0.167	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	6.167 1.33
0.333	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	6.334 0.61
0.500	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	6.500 0.25
0.667	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	6.667 0.24
0.833	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	6.834 0.24
1.000	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	7.000 0.24
1.167	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.04	7.167 0.24
1.333	0.02	0.02	0.02	0.03	0.04	0.04	0.03	0.04	7.334 0.23
1.500	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04	7.500 0.21
1.667	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05	7.667 0.20
1.833	0.02	0.03	0.03	0.04	0.04	0.05	0.06	0.05	7.834 0.19
2.000	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.05	8.000 0.19
2.167	0.03	0.04	0.05	0.06	0.07	0.07	0.08	0.05	8.167 0.19
2.333	0.03	0.05	0.05	0.06	0.07	0.07	0.09	0.05	8.334 0.18
2.500	0.04	0.06	0.06	0.08	0.09	0.09	0.09	0.05	8.500 0.17
2.667	0.07	0.07	0.08	0.10	0.10	0.13	0.13	0.06	8.667 0.16
2.833	0.09	0.11	0.13	0.16	0.19	0.23	0.20	0.06	8.834 0.16
3.000	0.30	0.41	0.47	0.56	0.63	0.71	0.83	0.07	9.000 0.16
3.167	0.40	0.55	0.66	0.75	0.85	0.98	1.16	0.16	9.167 0.09
3.333	0.20	0.26	0.30	0.36	0.41	0.47	0.51	0.16	9.334 0.06
3.500	0.08	0.09	0.10	0.13	0.14	0.16	0.17	0.16	9.500 0.06
3.667	0.04	0.06	0.07	0.08	0.09	0.10	0.09	0.16	9.667 0.05
3.833	0.03	0.05	0.06	0.07	0.08	0.08	0.09	0.17	9.834 0.05
4.000	0.03	0.04	0.05	0.06	0.07	0.07	0.09	0.18	10.000 0.05
4.167	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.19	10.167 0.05
4.333	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.19	10.334 0.05
4.500	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.19	10.500 0.05
4.667	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.21	10.667 0.04
4.833	0.02	0.02	0.02	0.03	0.04	0.04	0.04	0.22	10.834 0.04
5.000	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.24	11.000 0.04
5.167	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.24	11.167 0.04
5.333	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.24	11.334 0.03
5.500	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.24	11.500 0.03
5.667	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.25	11.667 0.03
5.833	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.26	11.834 0.02
6.000	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.96	12.000 0.02

TABLE A-4

## HISTORICAL RAINFALL WITH 48-HOUR ACCUMULATION OF 3.00 INCHES OR MORE

Year	Day	Q	Precip. Total	Loc.	Start. Hour	Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27			
1944	Jun 4	17800	4.28																																	
1949	Jul 26	840	0.63	M	1		0.10	0.14	0.01																											
	Jul 27	1070	4.77	M	3		0.01	0.04	0.05	0.01	0.01	0.08	0.90	1.25	2.49	0.25																		0.06		
1951	Jul 21	6060	3.95	M	22		0.27	3.14	0.17	0.37																										
1955	Jul 7	1810	0.37	M	19		0.23	1.31	0.07	0.01	0.24	1.28																								
	Jul 8	3510	4.96	M	1		0.38	1.71	0.09	0.01																										
1956	Aug 2	1820	2.50	M	2		0.01						0.01	0.16	0.12	0.50	0.80	0.05	0.02	0.02	0.04	0.02	0.11	0.16	0.12	0.32	0.27	0.06	0.01							
	Aug 3	2600	1.41	M	2		0.18	0.14	0.04	0.23	0.38	0.02																						0.06		
1957	Jun 22	8660	3.31	L	21		0.85	1.30	0.40	0.15	0.16	0.05	0.03	0.08	0.08		0.01	0.04	0.10	0.01														0.06		
	Jun 23	11600	0.20	L	19		0.02	0.12	0.05				0.06																							
1959	Jun 25	962	2.83	M	2		0.12							0.02			0.05				0.02	0.49	1.20	0.75	0.43	0.05	0.02									
	Jun 26	1470	0.78	M	4		0.46																													
1960	May 18	4480	0.13	L	10		0.05		0.03	0.15	0.07	0.02	0.09	0.21	0.15	0.07					0.02															
	May 19	5680	0.68	L	3		0.22	0.39	0.19																									0.17		
	May 20	7780	2.19	L	1		0.05	0.29	0.09	0.02	0.10	0.24																								
	May 21	12100	3.51	L	1		0.30	0.30	0.07	0.47	0.17	0.10	0.03	0.02	0.02	0.31	0.09	0.02	0.09	0.02	0.03	0.02	0.02											0.34		
1968	Jun 13-14	4680	3.87	M	9		0.09	0.16	0.63																										0.10	
1968	Jul 12	1880	0.68	M	4		0.19	1.38	0.20	0.02							0.03																	0.02		
	Jul 13	2520	1.34	M	1		0.01		0.05	0.17	0.25	0.21	0.07	0.26																				0.08		
	Jul 14	4240	2.30	M	1		0.02	0.02					0.89	0.06	0.10	0.01	0.15	0.03																0.05		
1978	Jun 15	3840	0.22	M	15		0.24	0.08		0.24	0.24	0.16																								
	Jun 16	3750	1.08	M	5		0.25																													
	Jun 17	4030	2.00	M	9		0.08										0.08		0.97		0.08													0.80		
1978	Aug 26	1070		M	22		0.03	0.15	0.63																											
	Aug 27	1180	3.51	M	1		0.79	0.80	0.29	0.54	0.19			0.04	0.02	0.01	0.02																			
1980	Jun 4	11000		M	19		0.04					0.03																								
	Jun 5	11900	0.38	M	1		0.06	0.02	0.49	0.90	0.15	0.02	0.01																						0.11	
	Jun 6	12500	1.32	M																															0.13	
	Jun 7	12900	1.69	M	1		0.04	0.85	0.28	0.01																									0.25	
1981	Jul 11-12	3920	3.00	L	1		0.29				0.11	1.29	0.50	0.33	0.48																				1.26	
1981	Aug 5-7	5720	3.16	M	4		0.78	0.32	0.16	0.16	0.32																								0.16	
1983	Jun 20	10700		M	9		0.30																													
	Jun 21-22	12600	3.12	M	9		2.55	0.27																												
1984	Aug 7-8	6960	5.10	M	24		0.07	0.29	0.11	1.10	0.11	2.31	0.24																						0.02	
1987	Jul 21	3100	7.83	M	19		0.27	2.91	0.49	0.31	0.64	1.05	1.61	0.39	0.16																				0.11	
1987	Jul 23-24	2490	3.25	M	20		0.75	0.87	0.84	0.16	0.35	0.28																							0.09	
1988	Aug 2			M	9		0.03							0.13	0.22	0.07	0.03																	0.04		
	Aug 3		0.61	M	3		0.01																												0.68	
	Aug 4-5		3.00	M	1		0.04	0.90	0.34	0.15	0.03																								0.18	
																																			0.03	
																																				0.12



TABLE A-5

HISTORICAL RAINFALLS WITH A DAILY TOTAL OF 0.4 INCHES OR MORE WHICH  
OCCURRED DURING OR JUST PRIOR TO A PERIOD OF BLOCKED GRAVITY DRAINAGE

Year	Date	Q	Precip. Total	Loc.	Start. Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1944	May 2	14700	1.16																											
	May 3	15800	1.99																											
	May 4	17400	0.46																											
	May 11	24100	0.78																											
	May 12	23200	0.07																											
	May 17	19000	0.39																											
	May 18	18800	0.45																											
	May 19	19000	0.23																											
	May 31	19300	0.13																											
	Jun 1	18500	0.53																											
	Jun 4	17800	4.28																											
	Jun 5	18800	0.22																											
1947	Jun 12	16300	0.02																											
	Jun 13	15800	1.11																											
	Jun 23	18000	1.05																											
	Apr 22	17400	0.23																											
	Apr 23	17600	0.33																											
	May 1	19700	0.57																											
	May 2	20000	0.40																											
	May 6	19400	0.54																											
	Jul 14	17800	0.76																											
	Mar 30	15700	0.29																											
	Apr 31	17900	0.45																											
1951	Apr 14	19500	0.58																											
	Apr 20	38700	0.07																											
	Apr 21	34500	0.75																											
	Apr 21	21200	0.11																											
	Apr 30	20500	1.29																											
	May 1-2	20500	1.29																											
	Jul 3	17100	0.43																											
	Jul 4	19400	0.05																											
	Jun 13	22900	0.89																											
	Aug 11	16100	0.51																											
	Jul 3	21700	1.83																											
1960	Apr 13	18600	1.07																											
	May 26	35100	0.57																											
	May 27	31700	0.25																											
	May 27	31700	0.25																											
	Jul 15	16500	0.52																											
	Apr 25-26	32800	0.94																											
	May 5	17500																												
	May 6	16100	0.47																											
	May 7	16100	1.48																											
	May 8	15500	0.61																											
	May 9	16200	1.01																											
1967	May 31	14800																												
	Jun 1	16400	1.30																											
	Apr 5	16300																												
	Apr 6-7	18900	1.36																											
	Apr 20-21	17100	0.69																											
	Jun 23	17100	0.56																											
	Jun 23	17100	0.56																											
	Mar 28	16400	0.43																											
	Apr 14	84500	0.01																											
	Apr 15	83500	0.50																											
	Apr 27	28600	0.55																											

TABLE A-5  
(Continued)

HISTORICAL RAINFALLS WITH A DAILY TOTAL OF 0.4 INCHES OR MORE WHICH  
OCCURRED DURING OR JUST PRIOR TO A PERIOD OF BLOCKED GRAVITY DRAINAGE

Year	Date	Q	Precip. Total	Loc.	Start. Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1972	Mar 21	16200	0.52	M		0.01	0.01							0.21	0.11	0.01				0.02	0.04	0.08	0.02												
	Jun 14	16800	1.17	M	20	0.47	0.70																												
	Apr 26	16100	0.08	M	15	0.02				0.02																									
	Apr 27	16800	1.46	M	2	0.06		0.13	0.28	0.30	0.02	0.05			0.09	0.45	0.13	0.03	0.02								0.04	0.06	0.04	0.01					
	Apr 28	17700	0.27	M	21	0.01	0.01																												
1975	May 7	16900	0.62	M	9	0.01	0.03	0.09	0.26	0.17	0.03	0.04																							
	May 8	18000	0.04	M	13	0.04																													
	Apr 12	24900	0.45	L	23	0.04	0.07																												
	Apr 13	24000	0.04	L	1	0.33	0.04	0.01																											
	May 1	19700	0.12	M	15	0.02	0.08	0.01	0.04	0.02	0.04	0.04	0.03	0.07	0.04																				
1979	May 2	19100	0.53	M	1	0.03	0.08	0.07	0.06	0.01	0.03	0.01																							
	Aug 29	23200	1.54	M	14	0.70	0.18	0.66																											
	Mar 5	26100	0.81	M	11	0.01	0.02	0.00	0.01																										
	Mar 6	27600	0.42	M	4	0.01	0.04	0.06	0.11	0.05																									
	Mar 7	28700	0.32	M	10	0.01	0.01																												
1983	Mar 16	23400	0.50	M	13	0.01	0.05	0.02	0.02	0.02	0.02	0.02	0.08	0.02	0.02	0.01	0.04	0.05	0.05	0.02															
	Mar 17	22000	0.04	M	6	0.02	0.04																												
	Apr 6	21400	0.46	M	1	0.01		0.02	0.05	0.03	0.02	0.09	0.04	0.04	0.05	0.06	0.01	0.03	0.01	0.01															
	Apr 13	26900	0.85	M	14	0.01	0.06	0.02	0.01	0.01	0.04	0.04	0.05	0.07	0.06	0.01																			
	Apr 14	28000	0.33	M	5	0.01	0.01	0.10	0.07	0.02																									
1984	Apr 15-16	30200	0.25	M	1	0.02	0.02	0.06	0.08	0.08	0.09	0.09	0.08	0.07	0.09	0.06	0.03	0.02	0.01	0.01															
	May 2	17000	0.81	L	1	0.07	0.11	0.12	0.16	0.13	0.08	0.05	0.03	0.07																					
	May 12-13	21700	0.90	M	1	0.01	0.05																												
	May 18	18900	0.01	M	17	0.01																													
	May 19-20	17900	0.42	M	2	0.01	0.03	0.02	0.08	0.01	0.04	0.15	0.07																						
1985	Jul 4	17300	1.43	M	13	1.28	0.15																												
	Apr 12	28000	0.45	M	10	0.01	0.04				0.01		0.01		0.01	0.01	0.01	0.01	0.01	0.01															
	Apr 13	28000	0.33	M	4	0.02	0.01	0.01		0.04	0.19	0.07	0.08	0.06																					
	Apr 14	28100	0.14	M	3	0.02	0.01	0.01	0.04																										
	Apr 15	28100	0.01	M	4	0.01	0.01	0.01	0.02																										
1986	Apr 26	21200	0.11	M	24	0.05	0.03																												
	Apr 27-28	20000	0.70	M	21	0.06	0.01																												
	Apr 30	17600	1.33	M	16	0.04	0.13	0.13	0.21	0.12	0.04	0.07	0.10	0.14	0.04	0.10	0.10	0.02	0.04	0.04															
	May 6	23600	0.03	M	23	0.14	0.69																												
	May 7-8	26100	1.07	M	1	0.10	0.03	0.06	0.02	0.03	0.01	0.01	0.02	0.01																					
1987	Jun 17	18200	0.40	M	9	0.03	0.26	0.10	0.13	0.32																									
	Jun 18	22900	0.69	M	11	0.14	0.03																												
	Jul 10-11	17100	2.64	L	7	0.75	0.18	0.02	0.32	1.03	0.33																								
	Mar 31	18600	0.15	M	10	0.01	0.02	0.03	0.02	0.02	0.04	0.03	0.06	0.14	0.11	0.13	0.10	0.06	0.06	0.06															
	Apr 1	18600	0.85	M	1	0.05	0.03	0.02	0.02	0.01																									
1988	Apr 23	11100	1.10	L	21	0.04	0.20	0.14	0.01	0.01	0.09	0.04	0.01	0.01	0.02	0.04	0.01																		
	Apr 24	14200	0.38	L	1	0.01	0.01																												
	Apr 3	27500	0.56	L	21	0.02	0.01	0.04	0.11																										
	Apr 4	27100	0.03	L	1	0.12	0.16	0.06	0.05																										
	Apr 5	27200	0.69	L	12	0.05	0.30	0.11	0.01	0.01																									
1989	Apr 6	27800	0.03	L	1	0.07																													
	Apr 14	32100	1.08	M	4	0.02		0.05	0.13	0.10	0.05	0.01																							
	Apr 15	31400	0.19	M	1	0.82																													
	Apr 19	28000	0.50	M	11	0.04	0.06	0.03	0.10	0.16	0.01		0.01																						
	Apr 20	27800	0.05	M	20	0.03	0.01																												
1990	Apr 27	25000	0.52	M	21	0.03		0.34	0.12																										
	Apr 28-29	26600	1.09	M	1	0.05	0.01	0.10	0.09	0.02																									
	May 10	24900	0.17	M	12	0.06	0.06	0.01	0.01	0.02	0.04	0.10	0.04	0.09	0.10	0.19	0.14	0.14																	
	May 11	23300	1.06	M	1	0.06	0.03	0.03	0.02	0.06	0.02																								
	Jun 21	12000	1.07	M	19	0.01	0.01				</																								

0.59 0.41 37 0.06

TABLE A-6

## INTERIOR WATERSHED CHARACTERISTICS

Section	1	2a	2b	2c	2d	2e	2f	3a	3b	3c	3d	3e	3f	3g
Area in Acres	36.0	10.1	8.7	6.6	9.1	8.7	5.2	8.9	7.5	5.7	15.9	10.5	5.2	7.9
Area in Square Miles	0.056	0.0157	0.0136	0.0104	0.0142	0.0136	0.0082	0.0138	0.0118	0.009	0.0248	0.0164	0.0081	0.0124
Max. Elev. - Feet		26	29.5	30	45.5	46	33	46	34.5	30	36.3	25	23	25
Mid Elev.			23	29	29	34		29	33		35	23.5		21
Min. Elev.		10	11	11	12	10	14	11	10	9	7	6	5	9
Length - Feet	2200	810	670	1050	1200	1150	860	1430	1360	990	1910	1150	1030	1340
Slope in Feet/feet	0.0170	0.0198	0.0276	0.0181	0.0279	0.0313	0.0221	0.0245	0.0180	0.0212	0.0153	0.0165	0.0175	0.0119
Sheet Flow Slope		0.0867	0.0217	0.0100	0.0550	0.0400	0.1100	0.0567	0.0050	0.1000	0.0093	0.0100	0.0767	0.0133
Street Slope		0.0867	0.0324	0.0189	0.0372	0.0424	0.1100	0.0159	0.0217	0.1000	0.0166	0.0190	0.0767	0.0115
Watershed Length in Feet														
Sheet Flow		300	300	100	300	300	300	300	300	300	140	150	300	300
Paved streets		510	370	950	900	850	560	1130	1060	690	1770	1000	730	1040
Manning's n Used for Sheet Flow		0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Two-Year, 24-Hour Rainfall - P2		3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Average Velocity, Shallow Concentrated Flow - fps		4.7	3.6	2.8	3.9	4.2	5.2	2.6	3.0	5.1	2.6	2.8	5.7	2.2
Time of Concentration - Hours														
Sheet Flow		0.329	0.573	0.324	0.395	0.448	0.299	0.390	1.030	0.311	0.437	0.448	0.346	0.696
Shallow Concentrated Flow		0.030	0.029	0.094	0.064	0.056	0.030	0.121	0.098	0.038	0.189	0.099	0.036	0.131
Total		0.359	0.601	0.418	0.459	0.505	0.329	0.511	1.128	0.348	0.626	0.548	0.381	0.827
Total In Minutes		21.6	36.1	25.1	27.5	30.3	19.7	30.6	67.7	20.9	37.6	32.9	22.9	49.6
Lag Time in Hours		0.340	0.216	0.361	0.275	0.303	0.197	0.306	0.677	0.209	0.376	0.329	0.229	0.496
Ratio of Impervious		0.30	0.35	0.35	0.35	0.35	0.35	0.45	0.45	0.45	0.45	0.45	0.45	0.45
SCS Curve Number (Antecedent Moisture Condition II)	93	81	81	81	81	81	81	83	83	83	83	83	83	83

TABLE A-7

## UNIT HYDROGRAPHS

Time In Hours	10-Minute Unit Hydrographs														60-Minute Unit Hydrographs	
	Section:														Section	
	1	2a	2b	2c	2d	2e	2f	Total Section 2							2	3
0.167	19	15	4	7	8	6	9	49	6	1	9	7	6	7	2	38
0.333	59	25	13	15	19	16	13	101	17	3	14	22	18	12	6	92
0.500	61	12	14	10	15	15	6	72	15	6	7	26	18	7	10	89
0.667	38	5	10	4	7	8	2	36	8	7	3	19	10	3	10	60
0.833	19	2	5	2	3	4	1	17	4	7	1	10	5	1	8	36
1.000	10	1	3	1	2	2	0	9	2	6	0	6	3	1	5	23
1.167	5	0	2	0	1	1	1	4	1	5	3	1	1	0	3	13
1.333	3	1	1	0	0	0	0	1	0	3	2	1	1	2	8	8
1.500	1	0	0	0	0	0	0	0	2	2	1	1	0	1	4	4
1.667	1	0	0	0	0	0	0	0	2	2	1	1	0	1	4	4
1.833	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
2.000									1	1					1	1
2.167									1	1					1	1
2.333															0	0
2.500																2
2.667																1
2.833																0

TABLE A-8

## RUNOFF HYDROGRAPHS

100 - Percent Event

Hours	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Runoff
0.167	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	3
0.667	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.833	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
1.000	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
1.167	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2
1.333	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	2
1.500	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	2
1.667	1	0	0	0	0	0	1	0	0	0	1	0	0	1	2	3
1.833	1	0	0	1	0	0	2	1	0	0	1	1	0	1	4	6
2.000	1	1	0	1	1	0	4	1	0	0	1	1	0	1	4	8
2.167	1	1	0	1	1	0	4	1	0	0	1	1	0	1	4	8
2.333	1	1	0	1	1	0	5	1	0	0	1	1	0	1	4	9
2.500	1	1	0	1	1	0	4	1	0	0	1	1	0	1	4	8
2.667	1	1	1	1	1	0	5	1	1	1	1	1	1	1	7	12
2.833	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
3.000	3	1	2	2	2	2	12	2	1	2	3	3	2	1	14	26
3.167	7	3	4	5	4	4	27	5	2	5	7	6	4	3	32	59
3.333	9	6	6	7	7	5	40	8	3	6	12	9	6	4	48	88
3.500	7	7	5	7	7	4	37	8	4	5	14	10	5	6	52	89
3.667	5	6	4	5	5	2	27	6	5	3	12	8	3	6	43	70
3.833	3	4	2	3	3	1	16	4	5	2	9	5	2	5	32	48
4.000	2	3	2	2	2	1	12	3	4	1	6	3	1	4	22	34
4.167	1	2	1	2	2	1	9	2	4	1	4	2	1	3	17	26
4.333	1	1	1	1	1	0	5	1	3	1	3	2	1	2	13	18
4.500	1	1	1	1	1		5	1	2	1	3	2	1	2	12	17
4.667	1	1	1	1	1		5	1	2	1	2	1	1	1	9	14
4.833	1	1	0	1	1		4	1	2	1	2	1	1	1	9	13
5.000	1	1		1	1		4	1	1	1	2	1	1	1	8	12
5.167	1	1		1	1		4	1	1	1	2	1	1	1	8	12
5.333	1	1		1	1		4	1	1	1	2	1	0	1	7	11
5.500	1	1		1	1		4	1	1	0	1	1		1	5	9
5.667	1	1		1	1		4	1	1		1	1		1	5	9
5.833	1	1		1	1		4	1	1		1	1		1	5	9
6.000	1	1		1	1		4	1	1		1	1		1	5	9
6.167	1	1		1	1		5	1	1		1	1		1	5	10
6.333	0	0		0	0		0	0	1		1	0		0	2	2
6.500								0			0				0	0

TABLE A-9  
RUNOFF HYDROGRAPHS  
40 - Percent Event

Hours	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Runoff
0.167	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500	1	0	0	0	0	0	2	0	0	0	1	0	0	0	3	5
0.667	1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	6
0.833	1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000	1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167	1	1	0	1	1	0	3	1	0	0	1	1	0	0	4	6
1.333	1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.500	1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	7
1.667	1	1	0	1	1	0	3	1	0	0	1	1	0	1	3	6
1.833	1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	7
2.000	1	1	0	1	1	0	4	1	0	0	1	1	0	1	4	8
2.167	1	1	0	1	1	0	4	1	1	0	1	1	0	1	5	9
2.333	1	1	1	1	1	0	6	1	1	1	1	1	1	1	8	14
2.500	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	15
2.667	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
2.833	2	1	1	1	1	1	7	2	1	1	3	2	1	1	11	18
3.000	4	2	2	3	2	3	16	3	1	3	5	4	3	2	21	37
3.167	11	5	6	7	6	6	41	8	2	8	11	9	6	4	48	89
3.333	14	9	9	12	10	8	62	12	4	10	19	14	8	7	74	136
3.500	11	10	8	11	10	6	56	12	6	7	21	14	7	9	76	132
3.667	7	9	5	8	8	3	40	9	7	4	18	11	4	9	62	102
3.833	5	6	3	5	5	2	26	6	7	3	13	8	3	8	48	74
4.000	3	4	2	4	4	2	19	4	7	2	9	5	2	6	35	54
4.167	2	3	2	3	3	1	14	3	6	1	6	4	1	4	25	39
4.333	2	2	1	2	2	1	10	2	4	1	5	3	1	3	19	29
4.500	1	2	1	1	2	1	8	2	4	1	4	2	1	3	17	25
4.667	1	1	1	1	1	1	6	2	3	1	3	2	1	2	14	20
4.833	1	1	1	1	1	1	6	1	2	1	3	2	1	2	12	18
5.000	1	1	1	1	1	1	6	1	2	1	3	2	1	2	12	18
5.167	1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	15
5.333	1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	15
5.500	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
5.667	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
5.833	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
6.000	1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
6.167	1	1	1	1	1	0	6	1	1	1	2	1	1	1	8	14
6.333	0	1	0	1	1		3	1	1	0	1	1	0	1	6	8
6.500		0		0	0		1	0	1		1	0		1	3	4
6.667							0		1		0			0	1	1
6.833								0			0				0	0

TABLE A-10

## RUNOFF HYDROGRAPHS

20 - Percent Event

Hours	1	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Total
0.167		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333		0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500		1	0	0	0	0	0	2	0	0	0	1	0	0	0	2	5
0.667		1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	5
0.833		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.333		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.500		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.667		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.833		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
2.000		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	7
2.167		1	1	1	1	1	0	4	1	1	1	1	1	1	1	5	9
2.333		1	1	1	1	1	1	4	1	1	1	2	1	1	1	6	10
2.500		1	1	1	1	1	1	5	1	1	1	2	1	1	1	7	12
2.667		1	1	1	1	1	1	6	1	1	1	2	2	1	1	9	14
2.833		2	1	1	2	1	1	8	2	1	2	3	2	1	1	12	20
3.000	0	5	3	3	4	3	3	21	4	1	4	6	4	3	2	25	46
3.167	1	14	6	8	9	8	8	53	10	3	9	13	10	8	4	57	110
3.333	2	18	11	11	15	13	10	78	15	5	12	23	17	10	8	89	167
3.500	3	14	13	10	14	13	7	70	15	7	9	26	18	8	11	92	163
3.667	3	9	11	7	9	10	4	49	11	8	5	22	13	5	11	75	124
3.833	2	6	8	4	6	6	3	33	7	9	3	16	9	3	9	56	89
4.000	1	4	5	3	4	5	2	23	5	8	2	11	6	2	7	42	64
4.167	1	3	4	2	3	3	1	17	4	7	2	8	5	2	5	31	48
4.333	0	2	3	2	2	3	1	13	3	5	1	6	3	1	4	24	37
4.500		2	2	1	2	2	1	10	2	4	1	5	3	1	3	19	29
4.667		2	2	1	2	2	1	8	2	3	1	4	2	1	3	16	24
4.833		1	2	1	1	1	1	7	2	3	1	3	2	1	2	14	21
5.000		1	1	1	1	1	1	6	1	2	1	3	2	1	2	12	18
5.167		1	1	1	1	1	1	6	1	2	1	3	2	1	2	10	16
5.333		1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	15
5.500		1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	14
5.667		1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
5.833		1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
6.000		1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
6.167		1	1	1	1	1	0	5	1	1	1	2	1	1	1	7	12
6.333		0	1	0	1	1		3	1	1	0	1	1	0	1	5	8
6.500			0		0	0		1	0	1		1	0		1	3	4
6.667								0		1		0			0	1	1
6.833								0		1						1	1
7.000										0						0	0
7.167																	

TABLE A-11  
RUNOFF HYDROGRAPHS  
10 - Percent Event

Hours	1	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Total
0.167		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333		0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500		1	0	0	0	0	0	2	0	0	0	1	0	0	0	2	5
0.667		1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	5
0.833		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.333		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.500		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.667		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	7
1.833		1	1	0	1	1	0	3	1	1	1	1	1	1	1	5	8
2.000		1	1	0	1	1	0	3	1	1	1	2	1	1	1	6	9
2.167		1	1	1	1	1	0	4	1	1	1	2	1	1	1	7	10
2.333		1	1	1	1	1	1	4	1	1	1	2	1	1	1	8	12
2.500		1	1	1	1	1	1	6	2	1	1	3	2	1	1	10	15
2.667		2	1	1	1	1	1	8	2	1	1	3	2	1	1	12	19
2.833		3	2	2	2	2	1	11	2	1	2	4	3	2	2	15	26
3.000		7	3	4	5	4	4	28	5	2	5	7	6	4	3	32	60
3.167		17	8	10	12	10	10	67	12	3	12	17	13	10	6	72	139
3.333		22	14	14	18	16	12	97	19	6	14	28	21	13	10	110	206
3.500	0	17	16	12	17	16	9	88	18	9	11	32	22	10	13	114	202
3.667	1	11	13	8	12	12	5	61	13	11	6	27	17	6	14	94	155
3.833	3	7	10	5	8	8	3	41	9	11	4	19	11	4	12	69	110
4.000	5	5	7	4	5	6	2	28	6	10	3	14	8	3	9	51	80
4.167	4	4	5	3	4	4	2	21	4	8	2	10	6	2	7	38	59
4.333	3	3	4	2	3	3	1	15	3	7	2	7	4	2	5	30	45
4.500	3	2	3	2	2	2	1	12	3	5	2	6	3	1	4	24	36
4.667	2	2	2	1	2	2	1	10	2	4	1	5	3	1	3	20	30
4.833	1	2	2	1	2	2	1	9	2	4	1	4	3	1	3	17	26
5.000	0	2	2	1	2	2	1	9	2	3	1	4	2	1	2	15	24
5.167		2	2	1	2	2	1	9	2	3	1	3	2	1	2	14	22
5.333		2	2	1	2	2	1	8	2	2	1	3	2	1	2	12	21
5.500		1	1	1	1	1	1	7	1	2	1	3	2	1	2	11	18
5.667		1	1	1	1	1	1	7	1	2	1	2	2	1	1	10	16
5.833		1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	15
6.000		1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
6.167		1	1	1	1	1	0	5	1	1	1	2	1	1	1	7	12
6.333		0	1	0	1	1		3	1	1	0	1	1	0	1	5	8
6.500			0		0	0		1	0	1		1	0		1	3	4
6.667								0		1		1			0	2	2
6.833								0		1		0				1	1
7.000									0							0	0
7.167																	



TABLE A-12

## RUNOFF HYDROGRAPHS

4 - Percent Event

Hours	1	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Total
0.167		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333		0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500		1	0	0	0	0	0	2	0	0	0	1	0	0	0	2	5
0.667		1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	5
0.833		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.333		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.500		1	1	0	1	1	0	3	1	0	1	1	1	1	1	5	8
1.667		1	1	0	1	1	0	3	1	1	1	2	1	1	1	7	10
1.833		1	1	0	1	1	0	3	1	1	1	2	1	1	1	6	9
2.000		1	1	1	1	1	0	3	1	1	1	2	1	1	1	6	9
2.167		1	1	1	1	1	1	4	1	1	1	2	1	1	1	7	11
2.333		1	1	1	1	1	1	4	1	1	1	2	2	1	1	9	13
2.500		2	1	1	1	1	1	6	2	1	1	3	2	1	1	10	16
2.667		2	2	1	2	2	1	10	2	1	2	3	2	1	1	12	22
2.833		3	2	2	3	2	2	13	3	1	2	5	3	2	2	17	30
3.000		9	4	5	6	5	5	34	6	2	6	9	7	5	3	38	72
3.167		21	10	12	15	12	12	82	14	4	14	20	16	11	7	86	168
3.333		26	17	17	22	19	14	115	22	7	17	33	25	15	12	131	246
3.500		20	19	15	20	19	10	103	21	10	12	37	25	12	16	133	236
3.667		13	16	10	14	14	6	73	15	12	7	31	19	7	16	107	180
3.833		8	11	6	9	9	4	47	10	13	5	22	13	5	13	81	128
4.000	0	6	8	4	6	7	3	34	7	12	3	16	9	3	10	60	94
4.167	2	4	6	3	5	5	2	25	5	10	2	11	7	2	8	45	70
4.333	5	3	4	2	3	4	2	18	4	8	2	9	5	2	6	36	54
4.500	8	3	3	2	3	3	1	15	3	6	2	7	4	2	5	28	43
4.667	6	2	3	2	2	2	1	12	3	5	2	6	3	1	4	24	36
4.833	5	2	2	1	2	2	1	10	2	4	1	5	3	1	3	19	29
5.000	4	2	2	1	2	2	1	9	2	4	1	4	3	1	3	18	27
5.167	2	2	2	1	2	2	1	9	2	3	1	4	2	1	2	15	24
5.333	1	2	2	1	2	2	1	9	2	3	1	3	2	1	2	13	22
5.500	0	2	2	1	2	2	1	10	2	2	1	3	2	1	2	12	21
5.667		2	2	1	2	2	1	10	2	2	1	3	2	1	2	12	21
5.833		1	1	1	1	1	1	6	1	2	1	3	2	1	2	11	17
6.000		1	1	1	1	1	1	6	1	2	1	2	2	1	1	10	16
6.167		1	1	1	1	1	1	6	1	1	1	2	1	1	1	7	13
6.333		0	1	0	1	1	0	3	1	1	0	2	1	0	1	6	8
6.500			1		0	0		2	0	1		1	1		1	4	5
6.667			0					0		1		1	0		1	2	2
6.833								0		1		0			0	1	1
7.000										0						0	0
7.167																	

TABLE A-13  
RUNOFF HYDROGRAPHS

2 - Percent Event

Hours	1	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Total
0.167		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
0.333		0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500		1	0	0	0	0	0	2	0	0	0	1	0	0	0	2	4
0.667		1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	5
0.833		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.333		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.500		1	1	0	1	1	0	3	1	0	1	1	1	1	1	5	8
1.667		1	1	1	1	1	0	4	1	1	1	2	1	1	1	6	10
1.833		1	1	1	1	1	1	4	1	1	1	2	1	1	1	7	11
2.000		1	1	1	1	1	1	5	1	1	1	2	1	1	1	7	12
2.167		1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	13
2.333		1	1	1	1	1	1	6	1	1	1	2	2	1	1	9	15
2.500		2	1	1	1	1	1	8	2	1	1	3	2	1	1	11	19
2.667		2	2	2	2	2	1	11	2	1	2	4	3	2	2	15	26
2.833		4	2	2	3	3	2	17	4	2	3	5	4	3	2	23	39
3.000		11	5	6	7	6	6	42	8	3	8	11	8	6	4	46	88
3.167		25	12	14	18	15	14	98	17	5	16	24	19	13	8	101	199
3.333		32	20	20	26	23	17	138	26	8	20	39	29	17	14	152	290
3.500		24	23	17	24	23	12	123	25	12	15	44	30	14	18	157	280
3.667		15	19	11	16	17	7	85	18	15	9	37	23	8	19	127	211
3.833		9	13	7	10	11	4	55	12	15	5	26	15	5	16	93	148
4.000	0	6	9	5	7	7	3	37	8	14	3	18	10	3	12	67	104
4.167	2	5	6	3	5	5	2	27	6	11	3	13	7	2	9	50	76
4.333	5	4	5	3	4	4	2	20	4	9	2	9	5	2	7	38	58
4.500	9	3	4	2	3	3	1	16	3	7	2	7	4	2	5	31	47
4.667	8	3	3	2	3	3	1	14	3	6	2	6	4	2	4	26	40
4.833	7	3	3	2	2	2	1	13	3	5	2	5	3	1	3	22	34
5.000	6	2	2	2	2	2	1	12	2	4	1	5	3	1	3	19	30
5.167	4	2	2	1	2	2	1	10	2	3	1	4	2	1	2	16	27
5.333	2	2	2	1	2	2	1	10	2	3	1	4	2	1	2	15	24
5.500	0	2	2	1	2	2	1	9	2	2	1	3	2	1	2	13	22
5.667		2	2	1	2	2	1	9	2	2	1	3	2	1	2	13	22
5.833		2	2	1	2	2	1	8	2	2	1	3	2	1	2	12	20
6.000		1	1	1	1	1	1	7	1	2	1	3	2	1	1	11	18
6.167		1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	15
6.333		0	1	0	1	1	0	3	1	1	0	2	1	0	1	6	9
6.500			1		0	0		1	0	1		1	1		1	4	5
6.667			0					0		1		1	0		1	2	2
6.833								0		1		0			0	1	1
7.000									0							0	0

TABLE A-14

## RUNOFF HYDROGRAPHS

1 - Percent Event

Hours	1	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Total
0.167		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333		0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500		1	0	0	0	0	0	2	0	0	0	1	0	0	0	2	5
0.667		1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	5
0.833		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.333		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	6
1.500		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	7
1.667		1	1	1	1	1	0	4	1	1	1	1	1	1	1	5	9
1.833		1	1	1	1	1	1	4	1	1	1	2	1	1	1	6	11
2.000		1	1	1	1	1	1	5	1	1	1	2	1	1	1	8	13
2.167		1	1	1	1	1	1	6	2	1	1	2	2	1	1	9	15
2.333		2	1	1	1	1	1	8	2	1	1	3	2	1	1	12	19
2.500		2	2	1	2	2	1	9	2	1	2	4	3	1	2	14	23
2.667		3	2	2	2	2	1	12	3	1	2	4	3	2	2	17	29
2.833		4	3	2	3	3	2	17	4	2	3	6	4	2	2	23	39
3.000		12	5	6	8	7	7	45	8	3	8	11	9	7	4	49	94
3.167		29	14	16	20	17	17	113	19	5	19	27	21	16	9	115	228
3.333		37	24	23	31	27	20	162	30	9	23	45	34	20	16	177	339
3.500		28	26	20	28	27	14	142	29	14	17	51	34	16	21	181	323
3.667		16	21	13	18	19	8	95	21	17	10	42	26	10	21	146	241
3.833		10	15	8	11	12	5	60	13	17	6	29	17	6	18	105	165
4.000	0	7	10	5	8	8	3	41	9	15	4	20	11	4	13	76	117
4.167	2	5	7	4	6	6	3	31	6	13	3	14	8	3	10	57	88
4.333	5	4	6	3	5	5	2	24	5	10	3	11	6	2	7	44	68
4.500	10	4	4	3	4	4	2	19	4	8	2	9	5	2	6	35	55
4.667	10	3	4	2	3	3	2	16	3	6	2	7	4	2	5	29	45
4.833	9	3	3	2	3	3	1	14	3	5	2	6	4	1	4	24	38
5.000	8	2	3	2	2	2	1	12	2	4	1	5	3	1	3	20	33
5.167	5	2	2	1	2	2	1	11	2	4	1	4	3	1	3	17	28
5.333	2	2	2	1	2	2	1	10	2	3	1	4	2	1	2	15	25
5.500	0	2	2	1	2	2	1	9	2	3	1	3	2	1	2	14	23
5.667		2	2	1	2	2	1	9	2	2	1	3	2	1	2	13	22
5.833		2	2	1	2	2	1	9	2	2	1	3	2	1	2	12	21
6.000		2	2	1	2	2	1	8	2	2	1	3	2	1	2	11	20
6.167		1	1	1	1	1	1	6	1	2	1	3	2	1	1	9	16
6.333		1	1	0	1	1	0	3	1	1	0	2	1	0	1	7	10
6.500		0	1		0	0		1	0	1		1	1		1	4	5
6.667			0					0		1		1	0		1	2	3
6.833								0		1		0			0	1	1
7.000										0						0	0

TABLE A-15

## RUNOFF HYDROGRAPHS FOR HISTORICAL EVENTS

(Gravity Conditions)

Location:	Section 1 - Total Runoff				Section 1 - Runoff To Section 2				Section 2				Section 3			
Event:	July 27 1949	July 21 1951	June 21 1983	July 21 1987	July 27 1949	July 21 1951	June 21 1983	July 21 1987	July 27 1949	July 21 1951	June 21 1983	July 21 1987	July 27 1949	July 21 1951	June 21 1983	July 21 1987
0.167	0	0	4	1	0	0	0	0	0	0	3	1	0	0	1	1
0.333	0	1	17	2	0	0	0	0	0	1	13	2	0	1	6	1
0.500	0	2	37	3	0	0	0	0	0	2	27	4	0	1	15	3
0.667	1	3	55	3	0	0	2	0	1	3	43	4	0	3	29	4
0.833	1	3	68	3	0	0	6	0	1	4	58	4	0	4	47	5
1.000	1	4	76	10	0	0	8	0	1	4	71	7	1	5	64	7
1.167	2	10	75	29	0	0	9	0	2	8	76	20	1	7	79	13
1.333	5	32	57	54	0	0	8	0	5	22	65	40	3	14	86	25
1.500	10	58	36	73	0	2	5	7	8	43	46	61	6	27	83	42
1.667	15	79	24	85	0	7	0	9	11	66	31	79	10	46	73	63
1.833	19	91	17	92	0	10		10	14	86	22	93	14	69	60	84
2.000	22	99	14	89	0	12		12	16	102	17	97	18	92	47	101
2.167	25	95	11	69	0	12		10	19	105	13	84	23	109	37	109
2.333	29	70	7	47	0	11		8	24	88	10	63	27	117	30	105
2.500	34	42	4	33	0	8		3	29	61	6	44	32	111	23	94
2.667	37	25	2	26	0	2		0	34	38	3	34	37	96	18	79
2.833	39	16	1	22	0	0			38	26	2	28	43	77	13	64
3.000	41	12	1	19	2				41	18	1	25	48	59	9	53
3.167	46	9	0	17	3				46	14	1	21	53	44	7	45
3.333	58	10		14	5				59	13	0	18	61	35	5	39
3.500	71	12		13	7				74	14		15	71	29	3	34
3.667	79	12		12	9				86	14		14	84	26	2	30
3.833	83	13		11	10				95	14		13	98	25	2	27
4.000	86	13		12	10				101	15		13	110	24	1	25
4.167	80	12		16	10				99	14		17	117	23	1	24
4.333	60	8		19	9				81	11		21	117	22	1	25
4.500	38	5		21	6				57	7		24	108	19	0	27
4.667	24	2		22	0				38	4		26	92	15		29
4.833	17	1		23					27	2		27	74	12		31
5.000	13	1		24					20	1		29	58	8		33
5.167	10	0		28					16	1		33	44	6		35
5.333	7			33					11	0		39	35	4		39
5.500	4			35					7			43	27	3		43
5.667	2			37					4			45	20	2		48
5.833	1			37					2			47	15	1		52
6.000	0			39					1			49	11	1		55
6.167				45					1			54	7	1		59
6.333				51					0			61	5	1		65
6.500				55								67	4	0		71
6.667				57								71	3			77
6.833				57								73	2			83
7.000				54								70	1			86
7.167				42								59	1			84
7.333				30								45	1			78
7.500				22								34	0			68
7.667				18								27				58
7.833				16								24				48
8.000				14								21				41
8.167				12								18				35
8.333				9								14				30
8.500				7								11				25
8.667				7								10				21
8.833				6								9				18
9.000				5								8				15
9.167				4								6				13
9.333				2								4				11
9.500				1								2				8
9.667				1								1				6
9.833				0								1				4
10.000												0				3
10.167																2
10.333																1
10.500																1
10.667																1
10.833																0

TABLE A-16

## RUNOFF HYDROGRAPHS

## Standard Project Storm

Hours	1	2a	2b	2c	2d	2e	2f	Total	3a	3b	3c	3d	3e	3f	3g	Total	Combined Total
0.167		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
0.333		0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	3
0.500		1	0	0	0	0	0	2	0	0	0	1	0	0	0	2	5
0.667		1	0	0	1	0	0	3	1	0	0	1	1	0	0	3	5
0.833		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.000		1	1	0	1	1	0	3	1	0	0	1	1	0	0	3	6
1.167		1	1	0	1	1	0	3	1	0	0	1	1	0	1	4	7
1.333		1	1	0	1	1	0	3	1	0	1	1	1	1	1	5	8
1.500		1	1	0	1	1	0	3	1	1	1	2	1	1	1	6	9
1.667		1	1	1	1	1	0	4	1	1	1	2	1	1	1	7	10
1.833		1	1	1	1	1	1	4	1	1	1	2	1	1	1	7	11
2.000		1	1	1	1	1	1	5	1	1	1	2	1	1	1	7	12
2.167		1	1	1	1	1	1	6	1	1	1	2	1	1	1	7	13
2.333		1	1	1	1	1	1	6	1	1	1	2	1	1	1	7	13
2.500		1	1	1	1	1	1	6	1	1	1	2	1	1	1	8	14
2.667		1	1	1	1	1	1	6	1	1	1	2	1	1	1	9	15
2.833		2	1	1	1	1	1	7	1	1	1	3	2	1	1	10	17
3.000		2	1	1	2	1	1	8	2	1	1	3	2	1	1	11	19
3.167		3	2	2	2	2	1	11	2	1	2	4	2	2	2	14	25
3.333		4	2	2	3	3	2	17	3	2	3	5	4	2	2	21	38
3.500		5	3	3	4	4	3	22	5	2	3	7	5	3	3	28	50
3.667		6	4	4	5	4	3	26	5	3	4	9	6	3	4	33	59
3.833		6	5	4	5	5	3	28	6	3	4	10	7	4	4	38	66
4.000		7	5	4	6	6	4	32	6	4	4	11	7	4	5	42	74
4.167		8	6	5	7	6	4	35	7	5	5	12	8	4	6	46	81
4.333		8	7	5	7	7	4	38	7	5	5	13	9	5	6	50	88
4.500		9	7	6	8	7	5	41	8	5	5	14	9	5	6	53	94
4.667		9	8	6	8	8	5	43	8	6	6	15	10	5	7	56	100
4.833		10	8	7	9	8	5	47	9	6	6	16	10	5	7	60	107
5.000		11	9	7	9	9	6	51	10	7	7	17	11	6	8	64	115
5.167		12	9	8	10	10	6	55	10	7	7	18	12	6	8	69	124
5.333		12	10	8	11	10	7	58	11	8	7	19	13	7	9	74	132
5.500		13	11	8	11	11	7	60	11	8	8	20	13	7	10	77	136
5.667	0	13	11	8	12	11	7	61	12	9	8	21	14	7	10	79	140
5.833	1	13	11	9	12	11	7	63	12	9	8	21	14	7	10	82	145
6.000	2	23	14	14	17	16	13	97	16	10	14	27	19	12	12	109	206
6.167	3	45	24	26	33	29	25	182	30	13	27	44	33	23	17	186	368
6.333	4	53	36	34	45	40	28	235	42	17	31	65	47	27	25	254	487
6.500	5	39	38	28	39	38	19	200	39	22	22	70	47	21	30	251	451
6.667	7	25	31	19	27	28	12	141	28	25	14	58	36	14	30	205	346
6.833	10	18	23	13	19	20	9	103	21	25	10	44	26	10	26	161	264

6.500	5	39	38	28	39	38	19	200	39	22	22	70	47	21	30	251	451
6.667	7	25	31	19	27	28	12	141	28	25	14	58	36	14	30	205	346
6.833	10	18	23	13	19	20	9	103	21	25	10	44	26	10	26	161	264
7.000	13	16	18	11	16	16	8	84	16	23	9	34	20	8	21	131	216
7.167	13	15	15	10	14	14	8	75	14	20	8	29	18	8	17	113	189
7.333	13	14	14	10	13	13	7	71	13	17	8	26	16	7	15	102	173
7.500	13	13	13	9	13	12	7	67	12	15	8	24	15	7	13	94	161
7.667	11	12	12	8	12	11	6	62	12	14	7	22	14	7	12	88	151
7.833	9	12	11	8	11	11	6	59	11	13	7	21	14	6	11	83	142
8.000	8	11	11	8	10	10	6	56	11	12	7	20	13	6	11	79	134
8.167	6	11	10	7	10	10	6	54	10	11	7	19	12	6	10	76	130
8.333	3	11	10	7	10	10	6	53	10	10	7	19	12	6	10	73	127
8.500	0	11	10	7	10	9	6	52	10	10	6	18	12	6	10	71	123
8.667		10	9	7	10	9	5	51	9	9	6	18	11	5	9	68	119
8.833		10	9	7	9	9	5	49	9	9	6	17	11	5	9	65	114
9.000		10	9	7	9	9	5	48	9	9	6	16	11	5	8	63	111
9.167		9	8	6	8	8	4	44	8	8	5	15	10	5	8	59	103
9.333		7	7	5	7	7	3	35	7	8	4	13	8	4	7	51	86
9.500		5	6	4	5	5	2	27	5	7	3	11	7	3	6	41	68
9.667		4	5	3	4	4	2	22	4	6	2	9	5	2	5	34	55
9.833		3	4	2	3	3	2	18	4	5	2	7	4	2	4	28	46
10.000		3	3	2	3	3	2	16	3	5	2	6	4	2	4	25	41
10.167		3	3	2	3	3	2	16	3	4	2	6	4	2	3	22	38
10.333		3	3	2	3	3	2	15	3	3	2	5	3	2	3	21	36
10.500		3	3	2	3	3	2	15	3	3	2	5	3	2	3	20	35
10.667		3	3	2	3	3	2	14	3	3	2	5	3	2	3	19	33
10.833		3	3	2	3	3	2	13	2	3	2	5	3	1	2	18	31
11.000		3	2	2	2	2	1	12	2	3	1	4	3	1	2	17	29
11.167		2	2	2	2	2	1	12	2	2	1	4	3	1	2	16	28
11.333		2	2	2	2	2	1	11	2	2	1	4	3	1	2	15	27
11.500		2	2	1	2	2	1	10	2	2	1	4	2	1	2	14	24
11.667		2	2	1	2	2	1	10	2	2	1	3	2	1	2	13	23
11.833		2	2	1	2	2	1	9	2	2	1	3	2	1	2	12	21
12.000		1	2	1	1	1	1	7	1	2	1	3	2	1	2	11	18
12.167		1	1	1	1	1	1	6	1	2	1	2	1	1	1	9	14
12.333		1	1	0	1	1	0	3	1	1	0	2	1	0	1	6	9
12.500		0	1		0	0	0	1	0	1	1	1	1	1	1	4	5
12.667			0					0	1	1	1	0			1	2	2
12.833								0	1	1		0			1	1	1
13.000								0	1	1					1	1	1
13.167								0	0						0	0	0

Table A-17

RUNOFF HYDROGRAPHS FOR HISTORICAL EVENTS WITH SIGNIFICANT RAINFALL  
AMOUNTS WHICH OCCURRED DURING A PERIOD OF HIGH RIVER STAGES  
(Sections 2 And 3 Combined)

Date:	Jun 13 1953	Jul 3 1957	Apr 13 1960	May 7-8 1965	Apr 6 1967	Jun 14 1972	Apr 27 1975	Aug 29 1979	Mar 6 1983	May 12-13 1983	Jul 4 1983	May 6-8 1984	Jul 10-11 1984	Apr 15 1986	Apr 27-29 1986
Minn. River															
Discharge-cfs.:	22900	21700	18600	16100	18000	16800	16800	23200	27600	21700	17300	26100	17100	32100	26600
Stage:	708.34	707.97	706.96	706.04	706.73	706.29	706.29	708.44	709.73	707.97	706.46	709.33	706.39	711.03	709.50
Time (Hours)	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	3	1	1	2	1	1	1	1	2	3	1	2	2	4
	5	11	2	6	4	5	1	1	7	7	14	4	7	8	10
	11	23	3	15	6	10	1	1	13	13	28	10	15	16	17
	15	32	4	31	9	18	2	2	17	16	4	16	18	18	19
	16	35	6	49	13	25	4	4	18	16	35	19	18	15	16
	14	33	7	58	17	25	6	6	22	13	23	16	14	10	11
	10	29	8	56	21	19	8	8	27	11	15	12	11	6	6
	6	23	8	47	22	12	11	11	27	9	9	8	11	3	4
	4	17	9	37	20	7	12	12	21	6	6	6	17	2	2
	2	11	11	28	16	4	11	13	13	4	3	4	31	1	1
	1	7	12	22	11	3	9	8	8	3	2	3	46	1	1
	1	4	11	17	7	2	7	5	5	2	1	3	52	3	4
	0	2	9	12	4	1	6	3	3	2	1	3	48	2	2
	2	6	6	9	3	1	4	2	2	3	3	3	37	1	1
	7.5	1	4	6	2	0	3	1	1	2	0	3	24	0	0
	8.0	1	3	5	1		3	1	1	1	1	3	15	1	1
	8.5	3	3	4	1		5	0	1	0		2	9	0	0
	9.0	0	3	3	0		11		1			2	6		
	9.5	4	4	3	3		17		1			2	3		
	10.0	4	4	3	3		19		1			2	2		
	10.5	4	4	2	2		18		0			2	1		
	11.0	3	3	1	1		14					2	1		
	11.5	2	1	1	1		10					2	1		
	12.0	1	1	0			7					2	0		
	12.5	1	1				5					2			
	13.0	0	0				4					1			
	13.5						2					1			
	14.0						1					0			
	14.5						1								
	15.0						1								
	15.5						0								

TABLE A-18

INTERCEPTOR STORMSEWER DESIGN  
PLAN D

## STANDARD PROJECT STORM PLAN

Sewer Segment (4)	1A-2	2-3	3-4	4-5	5-6	6	7-6	7-8	8-9	9-10	10	11-10	12-11	13-12	14-13
Design (SPS) Discharge-Cfs.	57	93	127	172	212	240	-	42	59	90	254	99	52	25	(3) 0
Required Pipe Length-Feet	482	394	392	334	336	(2) 90	198	206	182	154	(2) 93	400	222	250	190
Required Pipe Diameter-Inches	42	54	60	66	72	72	30	30	36	48	66	48	36	24	18
Given Upstream Crown Level (1)	703.37	702.41	701.62	700.84	700.17	699.50	699.90	699.90	699.67	699.31	699.00	699.62	700.06	700.56	700.94
Upstream Invert Elevation	699.87	697.91	696.62	695.34	694.17	693.50	697.40	697.40	696.67	695.31	693.50	695.62	697.06	698.56	699.44
Standard Project Storm															
Discharge-Cfs.	57	93	127	172	212	240		42	59	90	254	99	52	25	0
Head-Feet	2.30	1.66	1.86	1.99	2.03	2.37		3.87	2.95	1.66	3.28	3.36	2.57	4.72	0
Hyd. Grad	710.90	708.60	706.94	705.08	703.09	*701.06		710.33	706.46	703.51	*701.85	705.21	707.78	712.50	0
1% - Event															
Discharge-Cfs.	37	61	84	115	142	162		29	43	60	161	71	37	21	0
Head-Feet	1.03	0.71	0.81	0.89	0.91	0.92		1.85	1.57	0.74	1.32	1.73	1.30	3.33	0
Hyd. Grad	703.11	702.08	701.37	700.56	699.67	*698.76		703.84	701.99	700.42	*699.68	701.41	702.71	706.04	0
10% - Event															
Discharge-Cfs.	22	36	50	68	84	96		18	27	38	115	45	23	13	0
Head-Feet	0.36	0.25	0.29	0.31	0.32	0.32		0.27	0.62	0.30	0.67	0.69	0.50	1.28	0
Hyd. Grad	*702.14	*700.55	*699.52	*698.61	697.22	*696.90		*700.09	*699.35	698.19	*697.89	*698.70	*699.40	700.68	0
20% - Event															
Discharge-Cfs.	20	31	42	57	70	80		15	22	31	94	37	19	11	0
Head-Feet	0.30	0.18	0.20	0.22	0.22	0.22		0.49	0.41	0.20	0.45	0.47	0.34	0.91	0
Hyd. Grad	*702.04	*700.42	*699.27	*698.35	697.20	*696.98		*699.68	*699.06	*697.88	*697.35	*698.39	*699.16	*700.40	0

## BLOCKED GRAVITY DESIGN (\*\*)

Pumping Station Located at Oak Street

Seepage Only

Discharge-Cfs.	1.8	2.2	2.6	3.3	6.6	-	10.8	14.0	16.8	18.4	-	15.9	11.9	9.0	9.0
Head-Feet	0.01	0.01	0.01	0.01	0.01	0.00	0.25	0.43	0.24	0.07	-	0.09	0.13	0.61	2.10
Hyd. Grad.	703.54	703.53	703.52	703.51	703.50	703.49	703.49	703.24	702.81	702.57	702.50	702.59	702.72	703.33	705.43
Gravity															
Discharge-Cfs.	5.2	7.9	11.0	15.0	18.3	-	21.0	24.5	25.1	28.1	-	7.5	3.7	1.2	1.2
Head-Feet	0.02	0.01	0.01	0.02	0.02	0.00	0.94	1.32	0.53	0.16	-	0.02	0.01	0.01	0.04
Hyd. Grad.	705.53	705.51	705.50	705.49	705.47	705.45	705.45	704.51	703.19	702.66	702.50	702.52	702.53	702.54	702.58

\* Inlet control.

\*\* See Table A-19.

(1) Assumes a pipe slope of 0.002. Outlets B and C are to be laid with an outlet invert elevation of 693.0.

(2) Distance from interceptor sewer to gatewell.

(3) This sewer segment is required to carry seepage runoff only.

(4) Sewer segments refer to the locations as shown on Drawing Sheet 16.



TABLE A-19

## DESIGN DISCHARGE RATES

## Distribution Of Runoff During Blocked Conditions - Seepage Only

Inlet No. (***)	Station	Contrib. Watershed Location	Street Location	Design Q:				Seepage Levee		Accum. Seepage ((Ft./Hd.))	Accumulated Seepage (Gpm.)**	Average Seepage Rate In Pipe (Cfs.)	Pipe Discharge Location	Cfs.
				1%	SPS	10%	20%	Length	Seepage (FT./HD.)* Per Section					
1A	76+35	1,2A	Spruce	37	57	22	20	1655	31.59	31.59	700	1.6		
2	71+15	2b	Hickory	24	36	14	11	520	9.93	41.52	920	2.1	1-2	1.8
3	67+05	2c	Elm	23	34	14	11	400	7.64	49.16	1089	2.4	2-3	2.2
4	63+03	2d	Cedar	31	45	18	15	380	7.25	56.41	1250	2.8	3-4	2.6
								320	6.11	62.52	1385			
5	59+51	2e	Pine	27	40	16	13	50	15.62	78.14	1732	3.9	4-5	3.3
6	55+88	2f	Chestnut	20	28	12	10	350	109.38	187.52	4155	9.3	5-6	6.6
7	53+94	3a		29	42	18	15	220	63.96	251.48	5573	12.4	6-7	10.8
8	51+85	3b	Walnut	14	17	9	7	220	63.96	315.44	6990	15.6	7-8	14.0
9	49+94	3c		17	31	11	9	170	49.42	364.86	8085	18.0	8-9	16.8
								240	69.76	434.62	9631	21.5		
10	47+95	3d	Oak	51	65	32	26	390	113.37	812.52	18005	40.1	9-10	18.4
11	43+75	3e	Ash	34	47	22	18	160	46.51	264.52	5862	13.1	11-10	15.9
12	41+43	3f		16	27	10	8	240	69.76	218.01	4831	10.8	12-11	11.9
13	38+36	3g	Maple	21	25	13	11	510	148.25	148.25	3285	7.3	13-12	9.0
14	36+38													

(\*) Estimated seepage based on a 16-foot head is as follows:

Station 33+50 to Station 55+00 - 10,000 Gpm.

Station 55+00 to Station 59+00 - 2,000 Gpm.

Station 59+00 to Station 91+75 - 1,000 Gpm.

(\*\*) Based on a 22.16 foot head.

(\*\*\*) As shown on Drawing Sheet 16.

## Distribution Of Runoff During Blocked Conditions - Gravity Flow

Inlet No. (***)	Station	Contrib. Watershed Location	Street Location	Peak Unit Q	%	Acc. %	Accum. Runoff Gpm	Runoff Cfs
1A	76+35	1,2A	Spruce	25	13.0	13.0	2332	5.2
2	71+15	2b	Hickory	13	6.7	19.7	3544	7.9
3	67+05	2c	Elm	15	7.8	27.5	4943	11.0
4	63+03	2d	Cedar	19	9.8	37.3	6715	15.0
5	59+51	2e	Pine	16	8.3	45.6	8207	18.3
6	55+88	2f	Chestnut	13	6.7	52.3	9420	21.0
7	53+94	3a		17	8.8	61.1	11005	24.5
8	51+85	3b	Walnut	3	1.6	62.7	11285	25.1
9	49+94	3c		14	7.3	69.9	12591	28.1
10	47+95	3d	Oak	22	11.4	100.0	18000	40.1
11	43+75	3e	Ash	18	9.3	18.7	3366	7.5
12	41+43	3f		12	6.2	9.3	1674	3.7
13	38+36	3g	Maple	6	3.1	3.1	558	1.2
14	36+38							
Total				193	100.0			

TABLE A-20

## REQUIRED SIZE OF GRATED INLETS AND CONNECTING FEEDER PIPE

REQUIRED SIZE OF GRATES										REQUIRED SIZE AND LEVEL OF FEEDER PIPES									
Inlet Contrib. Design Q Approx. Max.				Based On A Single Inlet (6)				Based on One Inlet				Based on Two Inlets							
No. Wat'shed (10) Location	1% SPS	Rim Elev.	Pond Level (SPS)	Max. Allow. Head (Ft.) (1)	Permitted Area (SqFt.) (3)	Reqd. Area (A) (SqFt.) (4)	Recommended Area (2A) (SqFt.) (5)	Available Head In Feet (7)	RCP Pipe Size (Inches) (8)	Max. Allow. Invert Elev. (9)	RCP Pipe Size (Inches) (8)	Max. Allow. Invert Elev. (9)	RCP Pipe Size (Inches) (8)	Max. Allow. Invert Elev. (9)					
1A 2a	37	57	710 710.9	0.9	22.3	12.5	25.0	0.11	-	-	48	2.4	708.5						
2 2b	24	36	710 710.9	0.9	14.1	7.9	15.8	2.70	30	3.9	707.0	24	2.7	708.2					
3 2c	23	34	710 710.9	0.9	13.3	7.4	14.9	4.38	24	6.0	704.9	24	2.6	708.3					
4 2d	31	45	710 710.9	0.9	17.6	9.9	19.7	6.21	24	9.4	701.5	24	3.4	707.5					
5 2e	27	40	710 710.9	0.9	15.6	8.8	17.5	8.31	24	7.6	703.3	24	3.0	707.9					
6 2f	20	28	714 710.9	(2) 1.0	9.3	5.8	11.6	10.38	24	3.5	707.4	24	2.2	708.7					
7 3a	29	42	711 712.5	1.5	7.6	7.1	14.2	1.72	36	3.5	709.0	24	3.2	709.3					
8 3b	14	17	710 712.5	2.5	1.4	2.2	4.5	5.76	24	2.6	709.9	-	-	-					
9 3c	17	31	709 712.5	3.5	1.6	3.4	6.9	8.60	24	5.3	707.2	24	2.3	710.2					
10 3d	51	65	708 712.5	4.5	2.3	6.4	12.7	10.65	36	5.6	706.9	24	5.6	706.9					
11 3e	34	47	708 712.5	4.5	1.6	4.6	9.2	7.34	24	9.8	702.7	24	3.6	708.9					
12 3f	16	27	708 712.5	4.5	0.9	2.6	5.3	5.20	24	4.3	708.2	-	-	-					
13 3g	21	25	709 712.5	3.5	1.3	2.8	5.6	0.62	36	2.4	710.1	24	2.0	710.2					

(1) Allowable pond level, less rim elevation.

(2) Ground level in area will permit this condition.

(3)  $Q = 3 \cdot L \cdot H^{1.5}$ ,  $L = Q / (3 \cdot H^{1.5})$ (4)  $Q = 0.6 \cdot A \cdot (2 \cdot G \cdot H)^{0.5}$ ,  $A = Q / ((0.6 \cdot (2 \cdot G \cdot H)^{0.5}))$ 

(5) Assumes grate is 50 percent obstructed.

(6) With two inlets, the indicated requirements can be reduced 50 percent.

(7) Maximum allowable pond level (SPS), less resulting hyd gradient for SPS from Table A-18.

(8) Assumes a pipe length of 20 feet.

(9) Maximum allowable pond level, less HW.

(10) As shown on Drawing Sheet 16.

TABLE A-21

## ONE PERCENT AND SPS POND LEVELS

Location:	Section 2		Section 3	
Event:	1%	SPS	1%	SPS
Existing Conditions:				
Maximum Interior Pond Level	709.9	710.9	711.0	712.5
Estimated Damages In \$1000	0.0	0.0	255.0	420.0
Proposed Conditions:				
Maximum Interior Pond Level	703.2	710.9	706.0	711.5
Estimated Damages In \$1000	0.0	0.0	0.0	420.0

TABLE A-22

## ESTIMATED SEEPAGE DURING A STANDARD PROJECT FLOOD

Day	Flow In CFS		Minn. River Elev.	Head In Feet Above	Estimated Seepage (Gpm)
	At Mankato	At Chaska		706.0	
0	6000	6503	699.89		
1	7500	8129	701.52		
2	13000	14090	705.24		
3	22000	23845	708.63	2.63	2138
4	37500	40645	712.93	6.93	5634
5	57000	61781	717.26	11.26	9154
6	85000	92129	722.25	16.25	13211
7	105000	113806	725.30	19.30	15691
8	123000	133316	727.11	21.11	17162
9	136500	147948	728.26	22.26	18097
10	149500	162039	729.20	23.20	18862
11	155000	168000	729.58	23.58	19171
12	150500	163123	729.27	23.27	18919
13	142500	154452	728.70	22.70	18455
14	132500	143613	727.97	21.97	17862
15	121000	131148	726.93	20.93	17016
16	107500	116516	725.61	19.61	15943
17	91000	98632	723.23	17.23	14008
18	75000	81290	720.60	14.60	11870
19	63000	68284	718.38	12.38	10065
20	52500	56903	716.37	10.37	8431
21	44000	47690	714.54	8.54	6943
22	37500	40645	712.93	6.93	5634
23	31500	34142	711.54	5.54	4504
24	27000	29265	710.19	4.19	3406
25	24000	26013	709.30	3.30	2683
26	21500	23303	708.47	2.47	2008
27	19500	21135	707.82	1.82	1480
28	17500	18968	707.10	1.10	894
29	16500	17884	706.69	0.69	561
30	14500	15716	705.89		
31	14000	15174	705.67		
32	13000	14090	705.24		
33	12500	13548	705.02		
34	11500	12465	704.42		
35	11000	11923	704.12		

TABLE A-23

## PERIODS WHEN MINNESOTA RIVER EQUALLED OR EXCEEDED ELEVATION 706.0

October 1, 1934 Through September 30, 1987

(Q = 16,000 CFS.)

Year Dates From To	Number Of Days	Minnesota Peak Q In CFS.	River Peak Level	Precip. In Inches	Maximum Pond Levels					18000	20000	25000	Peak Runoff		
					No Pumping	5000 Gpm	10000 Gpm	15000 Gpm	Runoff (Cfs)				Seepage (Gpm)	Total (Gpm)	
1936 Mar 24 Mar 29	6	23200	708.4	1.62	711.80	706.00	-	-							
1943 Jun 17 Jun 26	10	25900	709.3	0.03	710.07	706.00	-	-							
1944 May 4 Jun 12	40	25100	709.0	8.51	717.00	711.62	710.24	706.00							
Jun 15 Jun 25	11	19100	707.1	1.19	711.40	710.01	706.00	-							
1945 Mar 18 Mar 22	5	17700	706.6	0.00	706.50	706.00	-	-							
Jun 17 Jun 22	6	18000	706.7	0.51	710.72	706.00	-	-							
1947 Apr 19 May 10	22	20422	707.6	2.29	712.22	706.00	-	-							
Jul 9 Jul 15	7	18300	706.9	0.86	711.09	706.00	-	-							
1948 Mar 23 Apr 3	12	21800	708.0	0.52	710.83	706.00	-	-							
1949 Mar 31 Apr 16	17	31600	710.9	1.03	711.51	710.17	706.00	-							
1951 Apr 9 May 11	33	62900	717.4	2.80	716.37	712.15	710.48	706.00							
Jul 3 Jul 8	6	19800	707.4	0.48	710.68	706.00	-	-							
1952 Apr 3 May 7	35	59100	716.8	1.09	716.11	711.65	710.33	706.00							
1953 Jun 12 Jun 17	6	22900	708.3	0.92	711.21	710.24	706.00	-							
Aug 8 Aug 9	2	16300	706.1	0.05	710.76	706.00	-	-							
Aug 11 Aug 12	2	16100	706.0	0.51	710.69	706.00	-	-							
1957 Jun 25 Jul 6	12	40200	712.8	2.28	713.59	710.84	710.32	708.50	706.00	-	-		35	1620	17330
1960 Apr 4 Apr 21	18	24200	708.7	1.09	711.31	710.06	706.00	-							
May 23 Jun 1	10	35100	711.8	0.84	711.91	711.38	706.00	-							
1962 Apr 2 Apr 28	27	39400	712.7	0.74	712.64	710.27	706.00	-							
May 25 May 28	4	17100	706.4	0.56	710.77	706.00	-	-							
Jul 13 Jul 15	3	16500	706.2	0.52	710.70	706.00	-	-							
1965 Apr 8 May 7	30	112000	725.1	4.55	718.42	717.20	714.66	711.13	709.70	709.20	708.10		58	30	26030
May 9 May 15	7	17200	706.4	1.35	711.54	706.00	-	-							
Jun 1 Jun 4	4	16600	706.2	1.40	711.58	706.00	-	-							
Jun 12 Jun 13	2	16800	706.3	0.00	706.20	706.00	-	-							
1966 Apr 6	1	16000	706.0	0.00	706.00	-	-	-							
1967 Apr 7 Apr 12	8	19300	707.2	1.42	711.59	710.32	706.00	-							
Jun 21 Jun 24	4	17500	706.5	1.04	711.45	706.00	-	-							
1968 Oct 20 Nov 2	14	37200	712.3	0.19	711.92	710.24	706.00	-							
1969 Mar 28 May 12	46	84500	721.1	2.61	717.16	714.63	711.55	706.00	-	-	-		4	12270	14060
1971 Mar 20 Apr 10	22	24100	708.7	0.15	710.30	706.00	-	-							
1972 Mar 21 Mar 24	4	16600	706.2	0.52	710.71	706.00	-	-							
Jun 13 Jun 16	4	16800	706.3	1.17	711.38	710.33	710.04	706.00	-	-	-		25	0	11220
1973 Mar 15 Mar 25	11	21500	707.9	0.62	710.85	706.00	-	-							
1975 Apr 26 May 9	14	22900	708.3	2.68	712.67	710.17	706.00	-							
1979 Apr 1 May 7	37	32000	711.0	1.67	712.24	710.23	706.00	-							
May 16 May 19	4	16600	706.2	0.27	710.38	706.00	-	-							
Aug 25 Sep 7	14	27200	709.6	1.97	712.00	710.87	710.26	706.00					27	2650	14770
1982 Mar 23 Mar 29	7	17200	706.4	0.01	710.01	706.00	-	-							
1983 Mar 2 Mar 25	24	30000	710.5	2.14	712.12	710.51	710.27	706.00					16	3610	10790
Apr 4 May 3	30	33300	711.3	3.13	712.79	710.17	706.00	-							
May 8 May 21	14	22100	708.1	1.35	711.54	706.00	-	-							
Jul 4 Jul 14	11	25500	709.1	1.43	711.61	710.60	710.22	708.10	706.00	-	-		35	410	16110
1984 Mar 29 May 20	53	33500	711.4	4.94	714.60	710.48	710.05	706.00					19	3360	11890
Jun 16 Jul 12	27	44800	714.0	4.16	715.34	711.38	710.81	709.70	709.10	708.70	706.00		52	240	23580
1985 Mar 16 Apr 11	27	31900	711.0	1.74	712.24	710.21	706.00	-							
Apr 25 May 7	13	20200	707.6	0.11	710.16	706.00	-	-							
1986 Mar 22 May 28	68	36600	712.2	7.59	716.14	710.61	710.13	706.00					18	5260	13340
Jun 23 Jul 3	11	26300	709.4	0.79	711.05	706.00	-	-							
Sep 24 Oct 7	14	24400	708.8	0.54	710.75	706.00	-	-							
TOTALS	819			77.98											

TABLE A-24

CONVERSION OF POND LEVELS INTO DAMAGES  
 GATE CLOSURE AT ELEVATION 706.0  
 PERIOD OF RECORD ANALYSIS

Elev.	Damages (\$1000)		Total	Frequency of Events in 100 Years				
	Section 2	Section 3		Station Capacity in Gpm				
				0	5000	10000	15000	20000
710.5		0	0	46.00	20.00	8.70	3.60	0.30
711.0	0	255	255	40.50	13.50	5.00	2.00	
711.5	140	300	440	35.00	9.80	4.00	1.10	
712.0	175	360	535	28.00	6.90	3.30	0.28	
712.5	210	420	630	21.00	5.80	2.90	0.025	
713.0	255	490	745	16.60	5.00	2.60		
713.5	300	565	865	15.20	4.40	2.30		
714.0	350	650	1000	14.60	4.10	2.10		
714.5	410	740	1150	14.30	3.90	1.90		
715.0	465	835	1300	13.80	3.30	1.60		
715.5	530	935	1465	12.00	3.00	1.05		
716.0	600	1040	1640	9.90	2.70	0.55		
716.5	675	1150	1825	7.60	2.30	0.23		
717.0	750	1270	2020	5.70	1.90	0.06		
717.5	835	1370	2205	4.00	1.45	0.013		
718.0	920	1485	2405	2.60	0.95			
718.5	1035	1575	2610	1.80	0.55			
719.0	1145	1660	2805	1.05	0.28			
719.5	1260	1730	2990	0.63	0.10			
720.0	1370	1800	3170	0.36	0.028			

TABLE A-25

## DETERMINATION OF AVERAGE ANNUAL PUMPING COSTS

Design Pump Capacity (Gpm)	Estimated Total Cost	First Costs (\$1000) Pumps Only (1)	Structure Only	Present Worth Pumps Energy & (2) Maintenance (3)	Total	Estimated Average Annual Cost (4)	
2000	50	22.5	27.5	23.9	7.9	59.3	5.27
5000	250	112.5	137.5	119.7	7.9	265.1	23.53
10000	350	157.5	192.5	167.6	7.9	368.0	32.66
15000	450	202.5	247.5	215.4	7.9	470.8	41.80
20000	550	247.5	302.5	263.3	7.9	573.7	50.93

(1) Pump cost assumed to be about 45% of total cost.

(2) Assuming pumps are replaced every 33 years with a 8.875% interest rate (1.0639).

(3) Estimated present worth of maintenance and energy costs:

(Obtained from pages E-6 and E-7 of St. Paul DM, dated March 1990.)

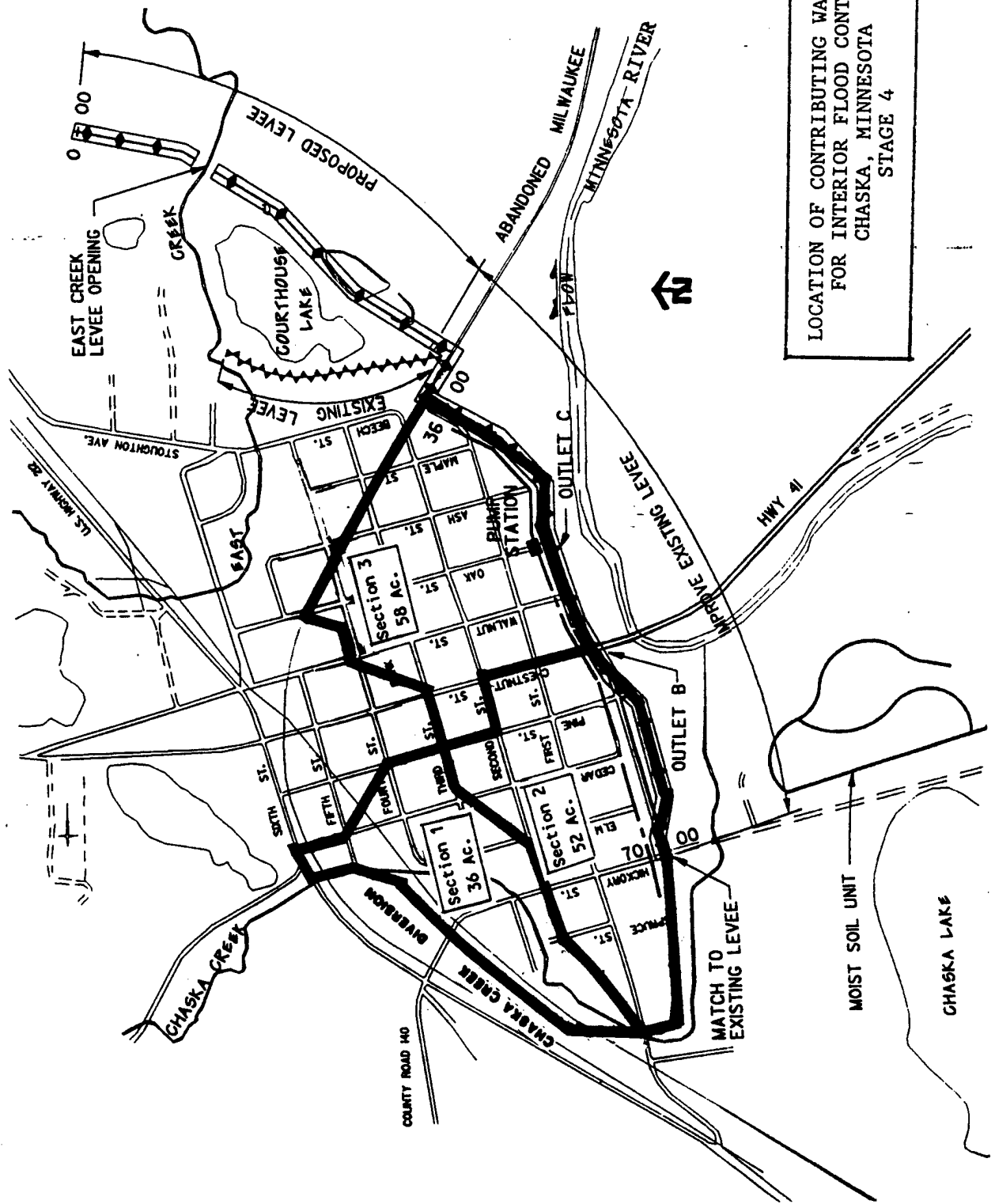
Energy Costs \$ 13949

Maintenance Costs 9818

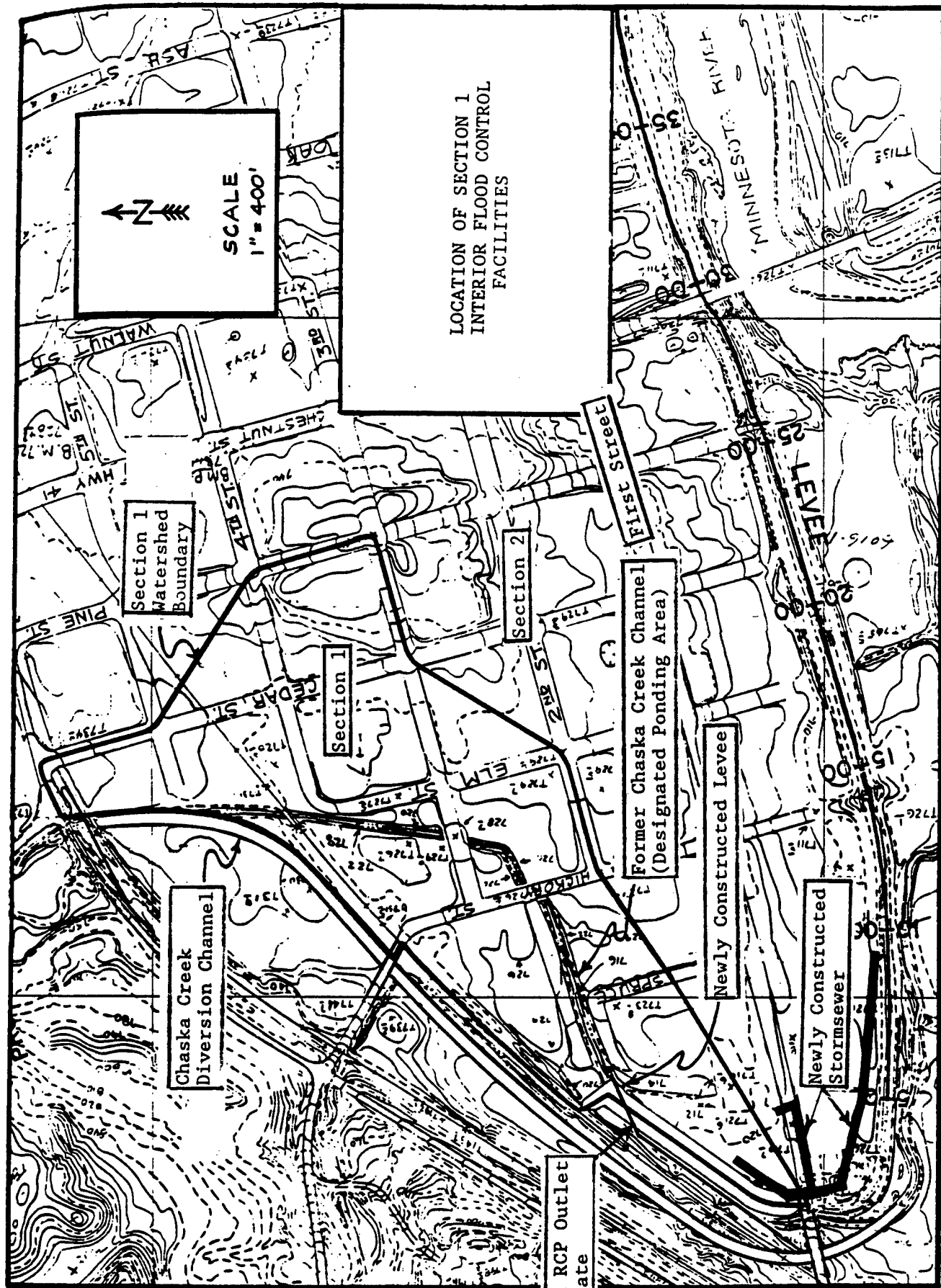
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Total \$ 23767 / 3 = \$ 7922

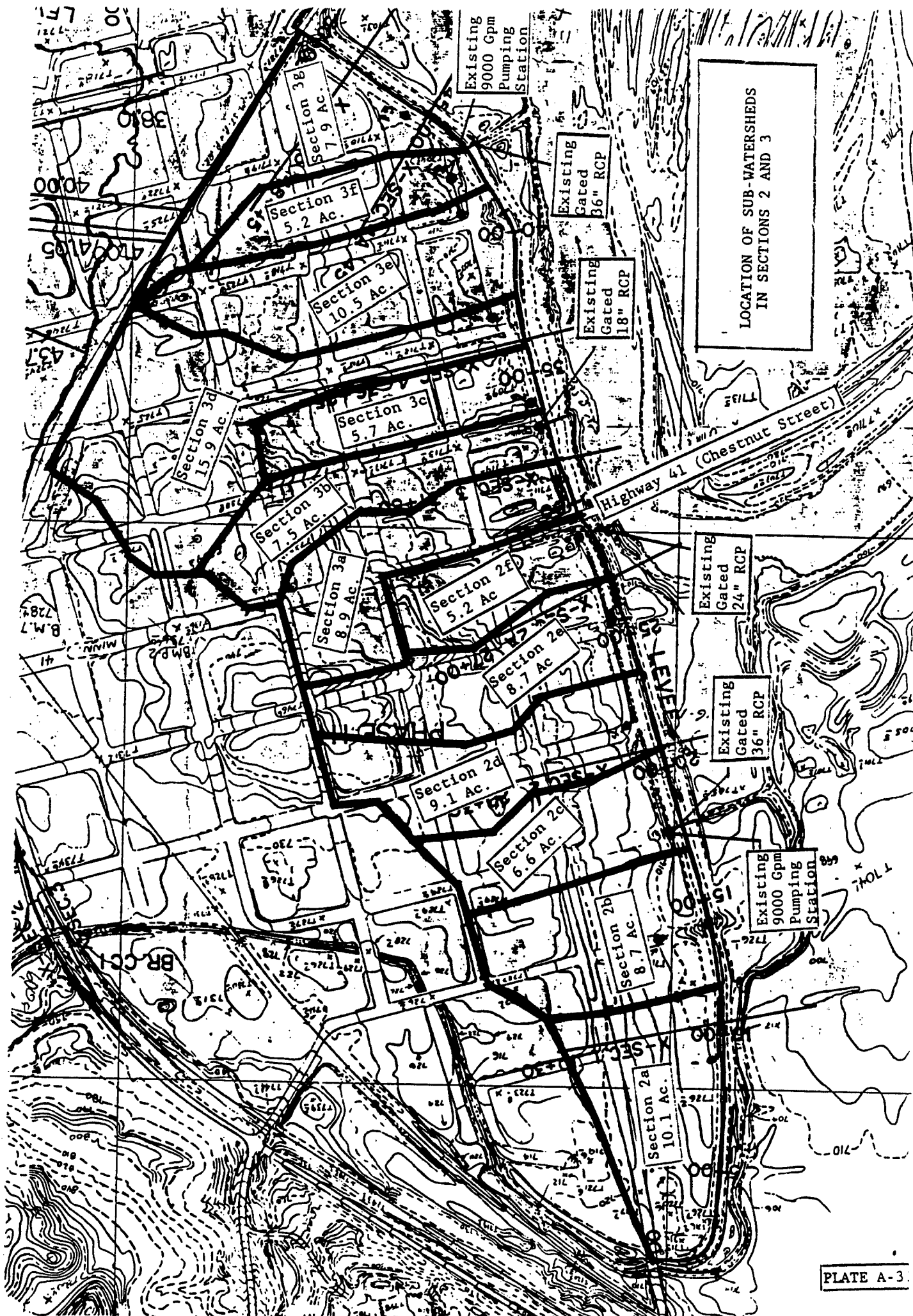
(4) Average amannual cost / present worth factor for a 100 year life is 0.08877.

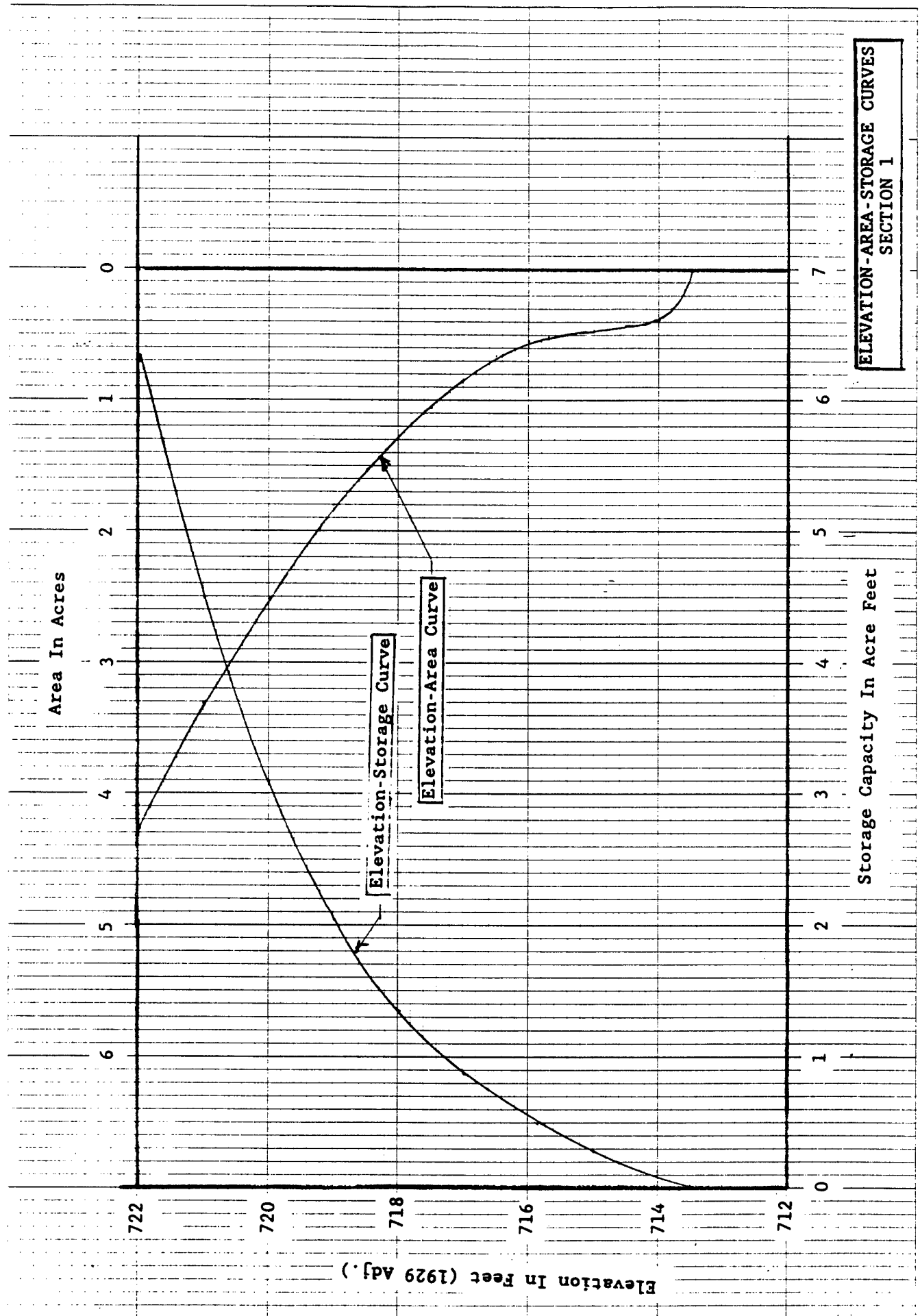


LOCATION OF CONTRIBUTING WATERSHEDS  
FOR INTERIOR FLOOD CONTROL  
CHASKA, MINNESOTA  
STAGE 4

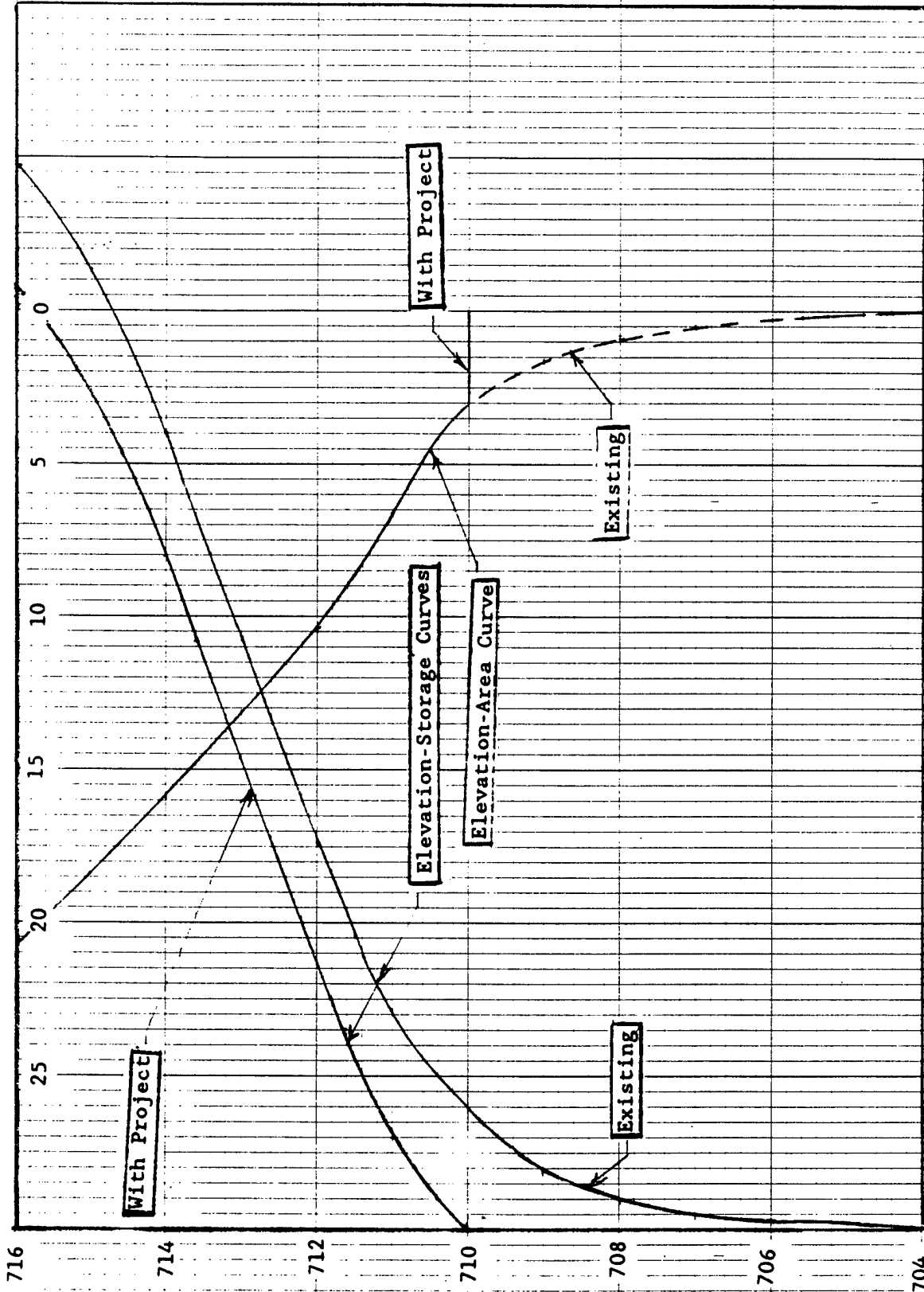








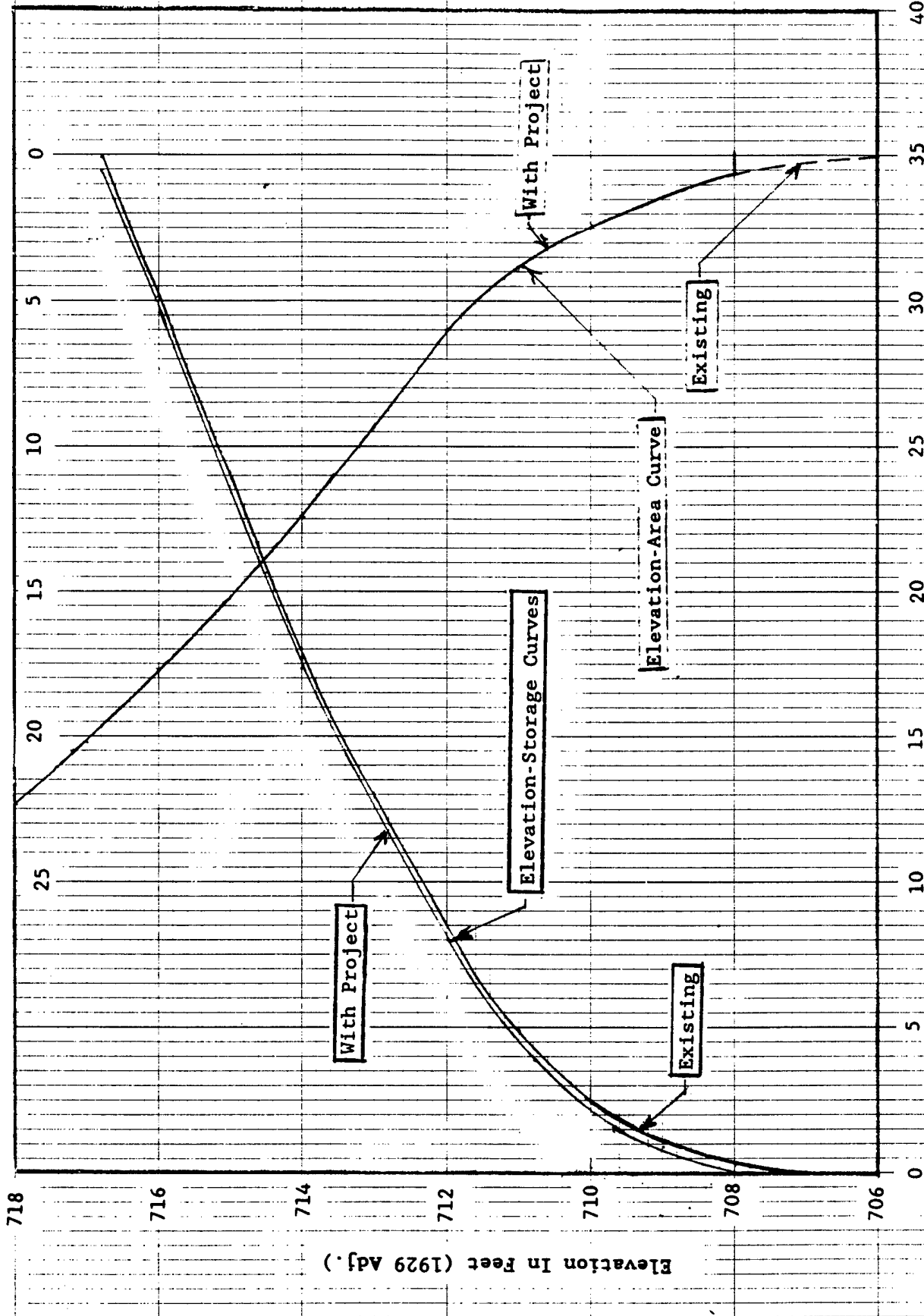
Area In Acres



ELEVATION-AREA-STORAGE CURVES  
SECTION 2

Storage Capacity In Acre Feet

Area In Acres



ELEVATION-AREA-STORAGE CURVES  
SECTION 3

Storage Capacity In Acre Feet

October 1990 Price Levels (ENR Building - 2700)  
July 1980 Conditions

720

718

716

714

712

710

Elevation In Feet (1929 Adj.)

Section 2

Section 3

DAMAGE - ELEVATION CURVES  
SECTIONS 2 AND 3

1400

1200

1000

800

600

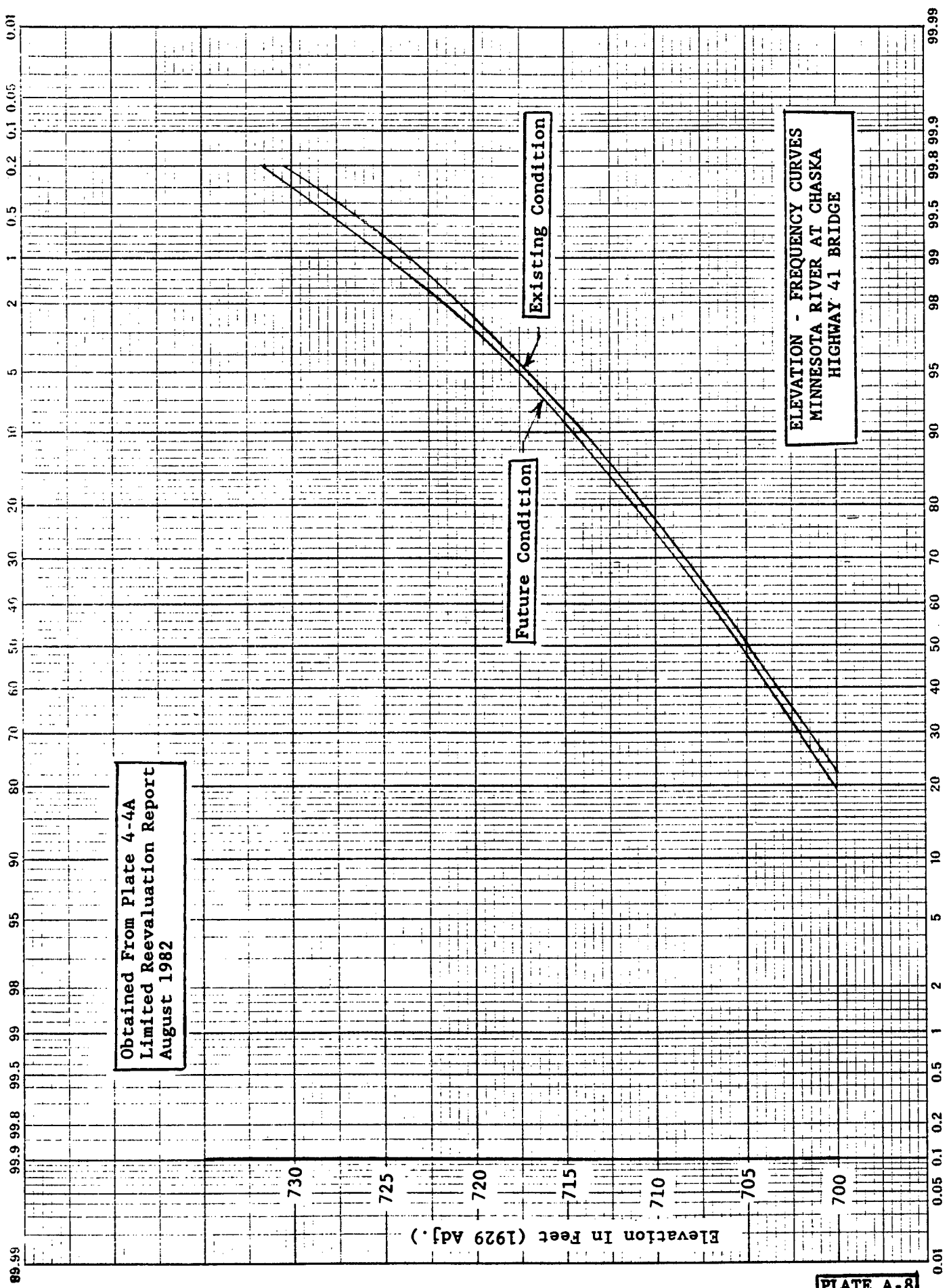
400

200

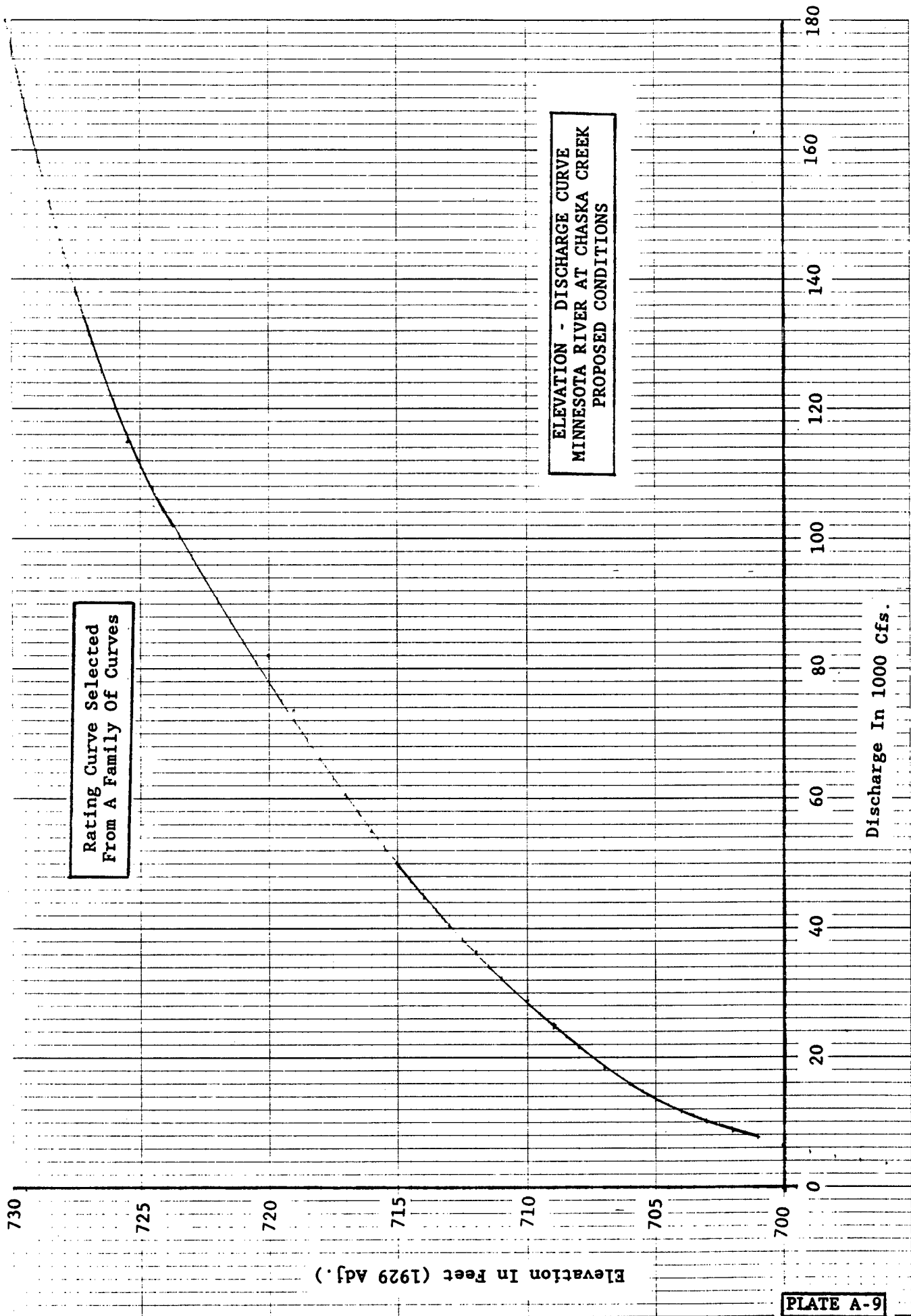
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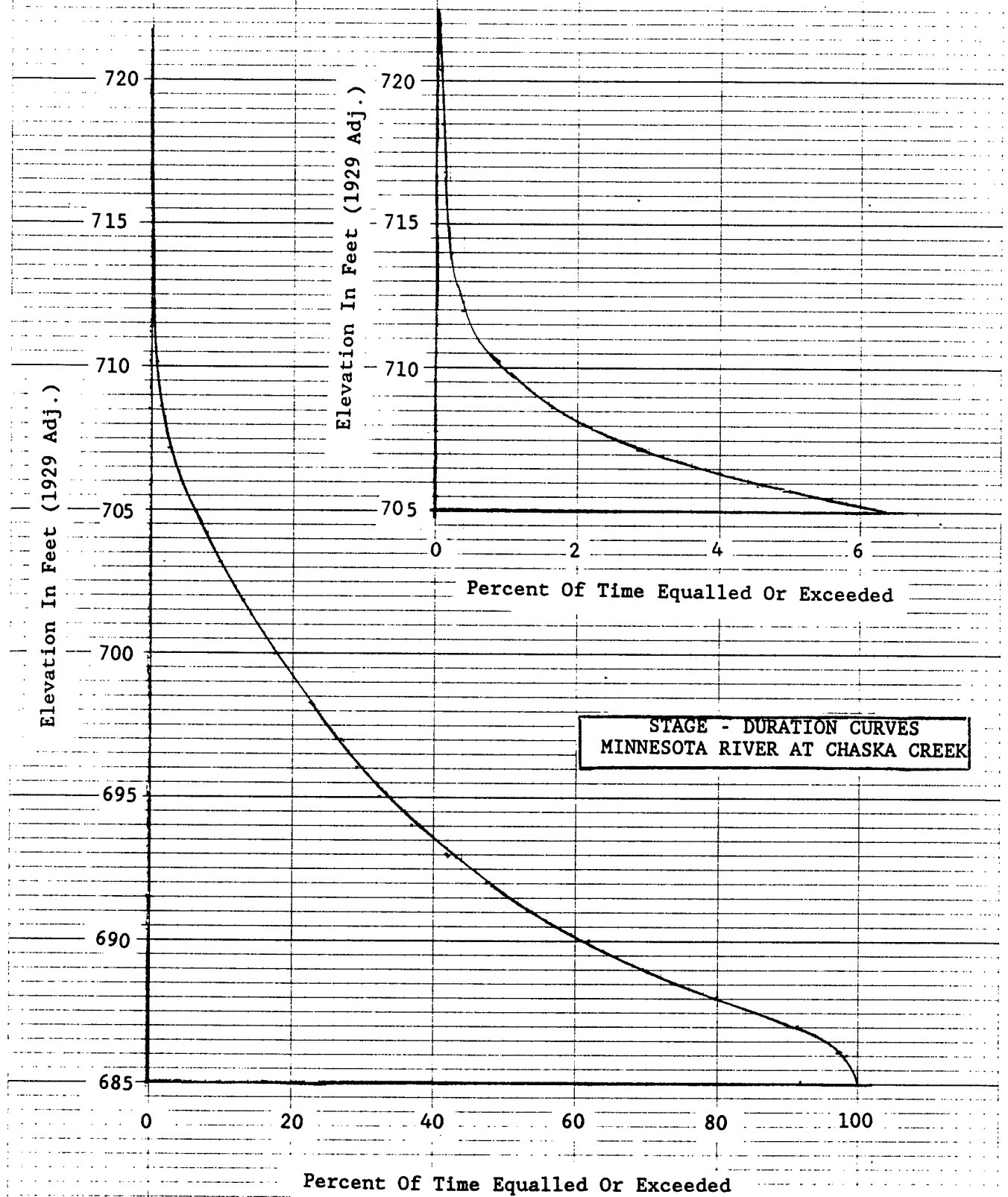
Damage In \$1000

Exceedance Frequency In Percent

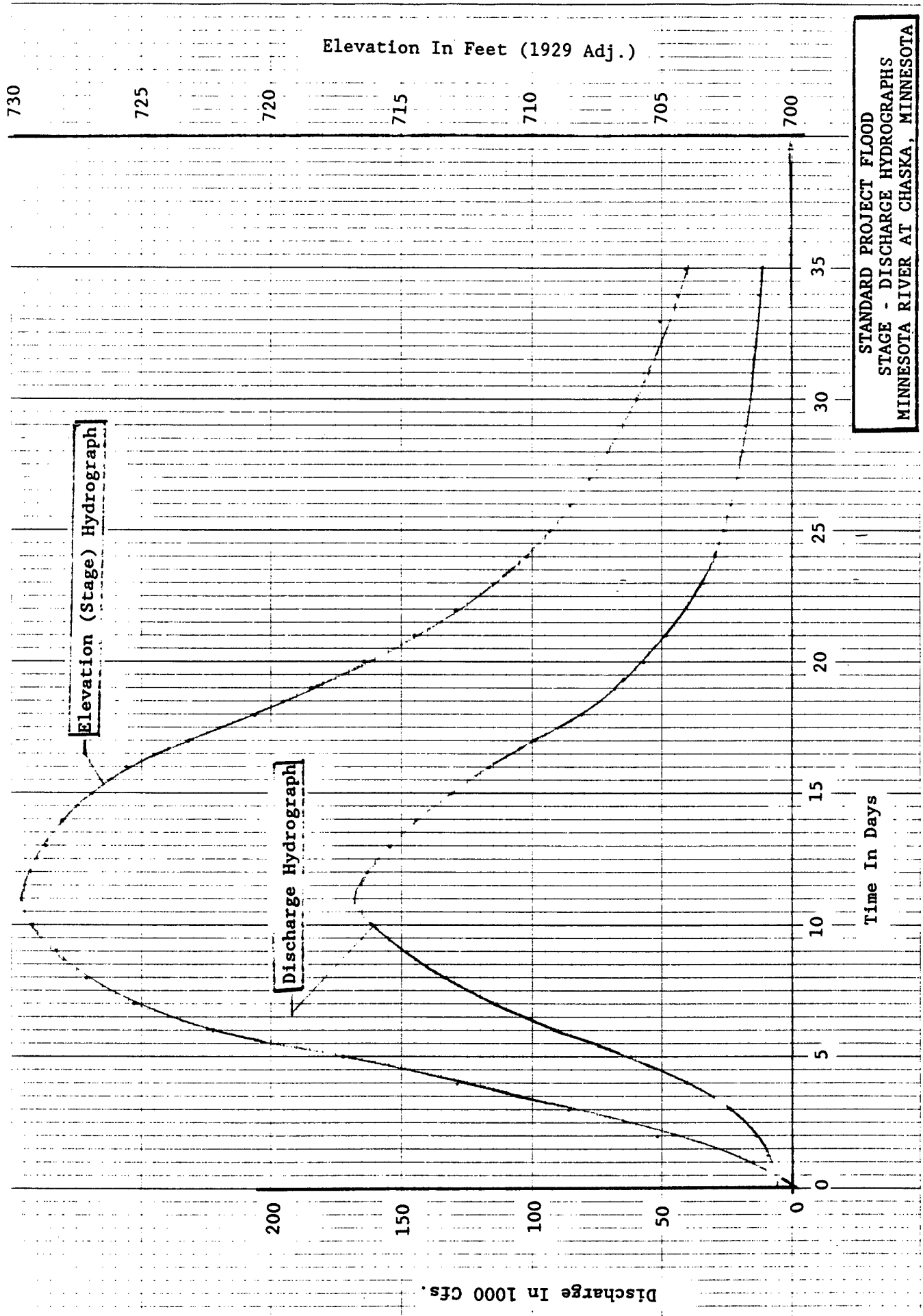


Obtained From Plate 4-4A  
Limited Reevaluation Report  
August 1982



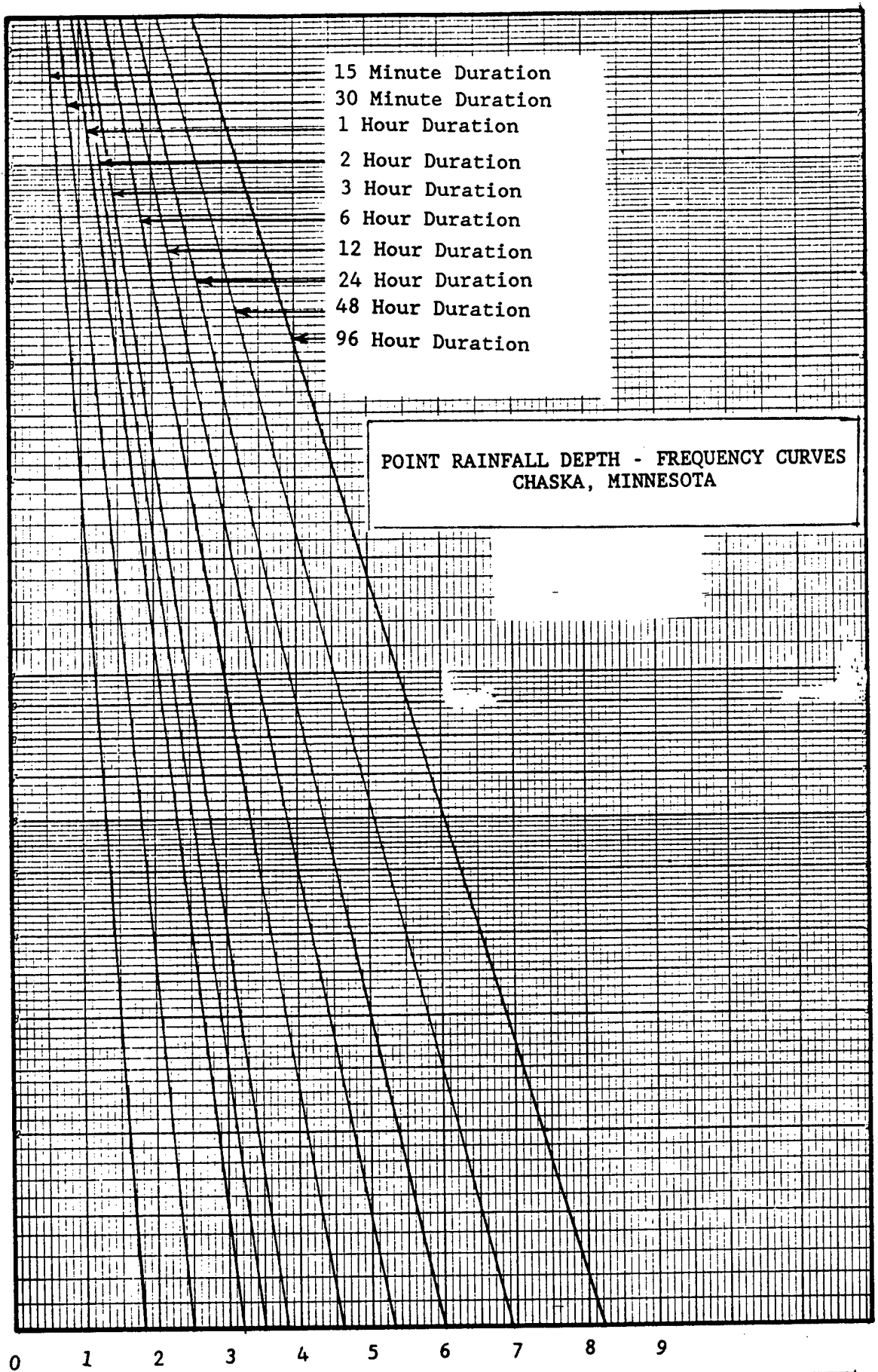




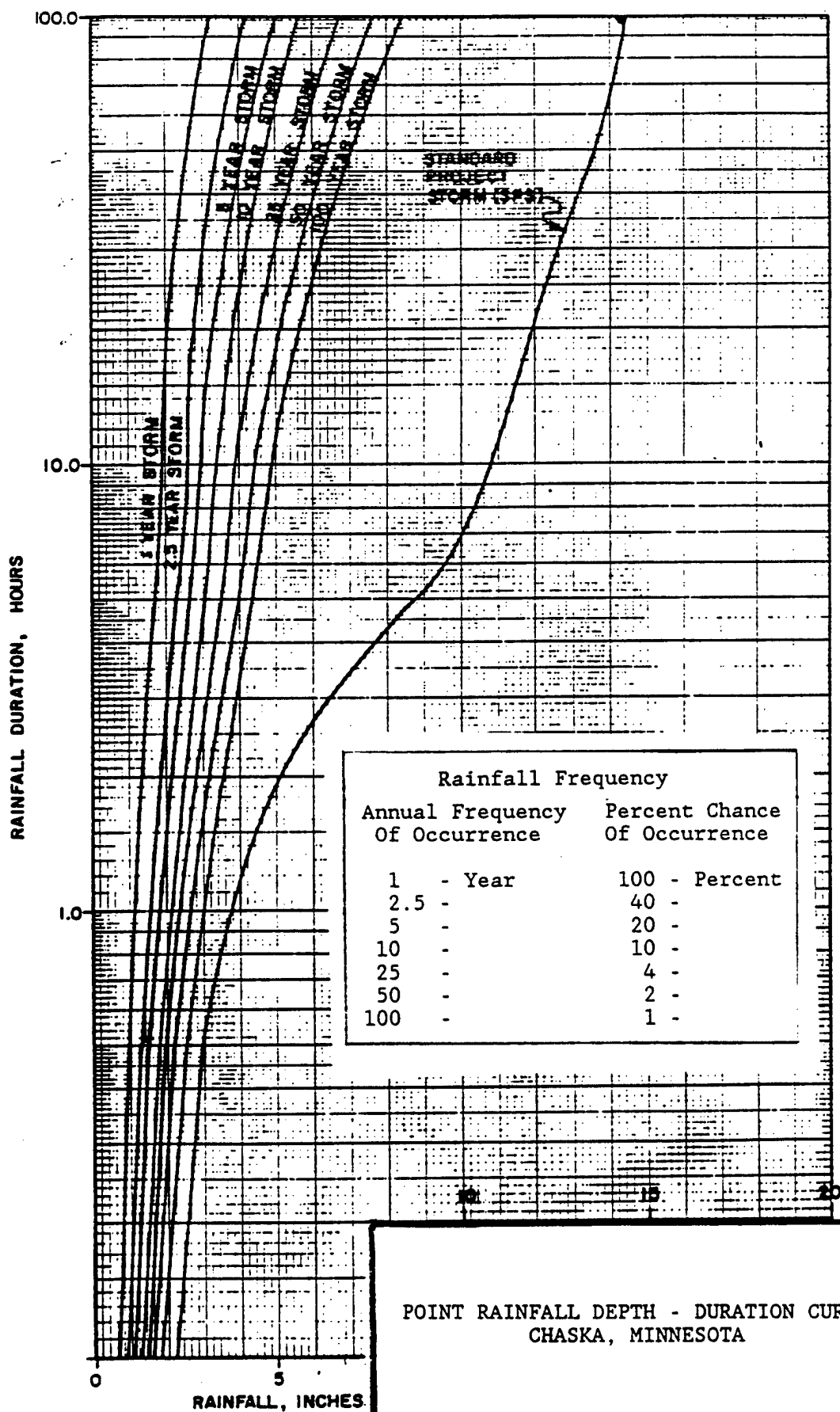


Rainfall Frequency In Events Per 100 Years

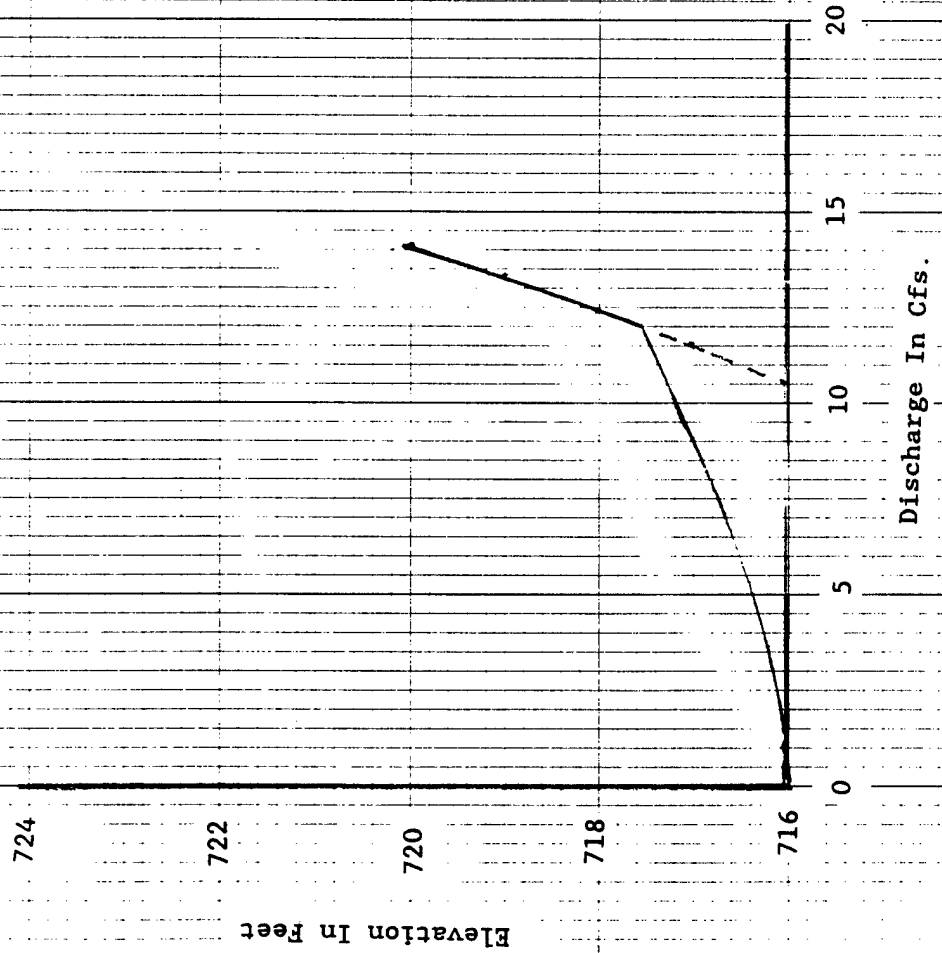
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50  
10  
5  
1



Point Rainfall Depth In Inches



POINT RAINFALL DEPTH - DURATION CURVES  
CHASKA, MINNESOTA



ELEVATION - DISCHARGE CURVE  
FOR  
EXISTING 24-INCH STORMSEWER  
FROM SECTION 1

18" RCP at Walnut St. - Section 3  
L=115', Inlet Invert El. = 703.0,  
Outlet Invert El. = 703.0

24" RCP at Highway 41 - Section 2  
L=100', Inlet Invert El. = 706.0,  
Outlet Invert El. = 706.0

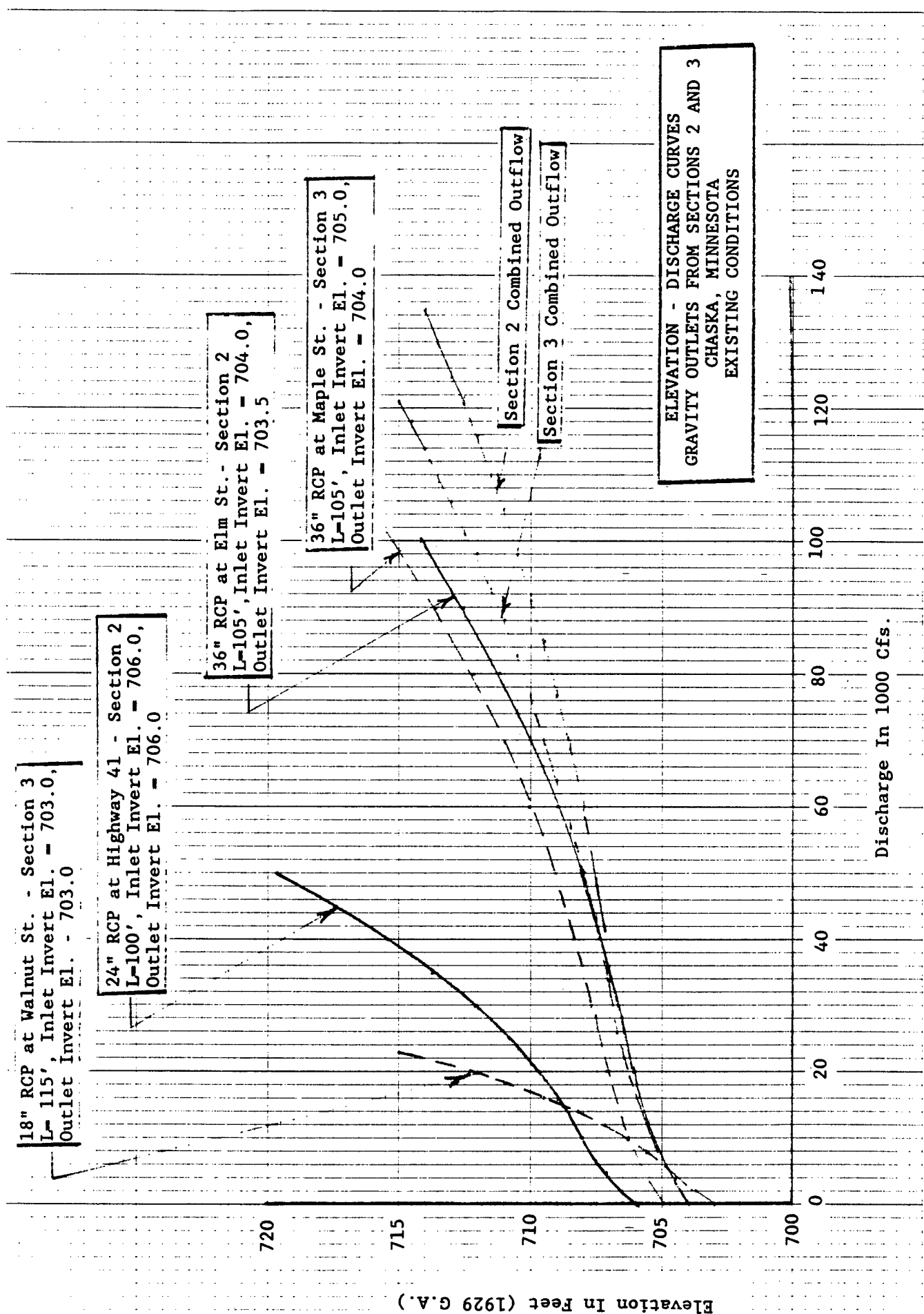
36" RCP at Elm St. - Section 2  
L=105', Inlet Invert El. = 704.0,  
Outlet Invert El. = 703.5

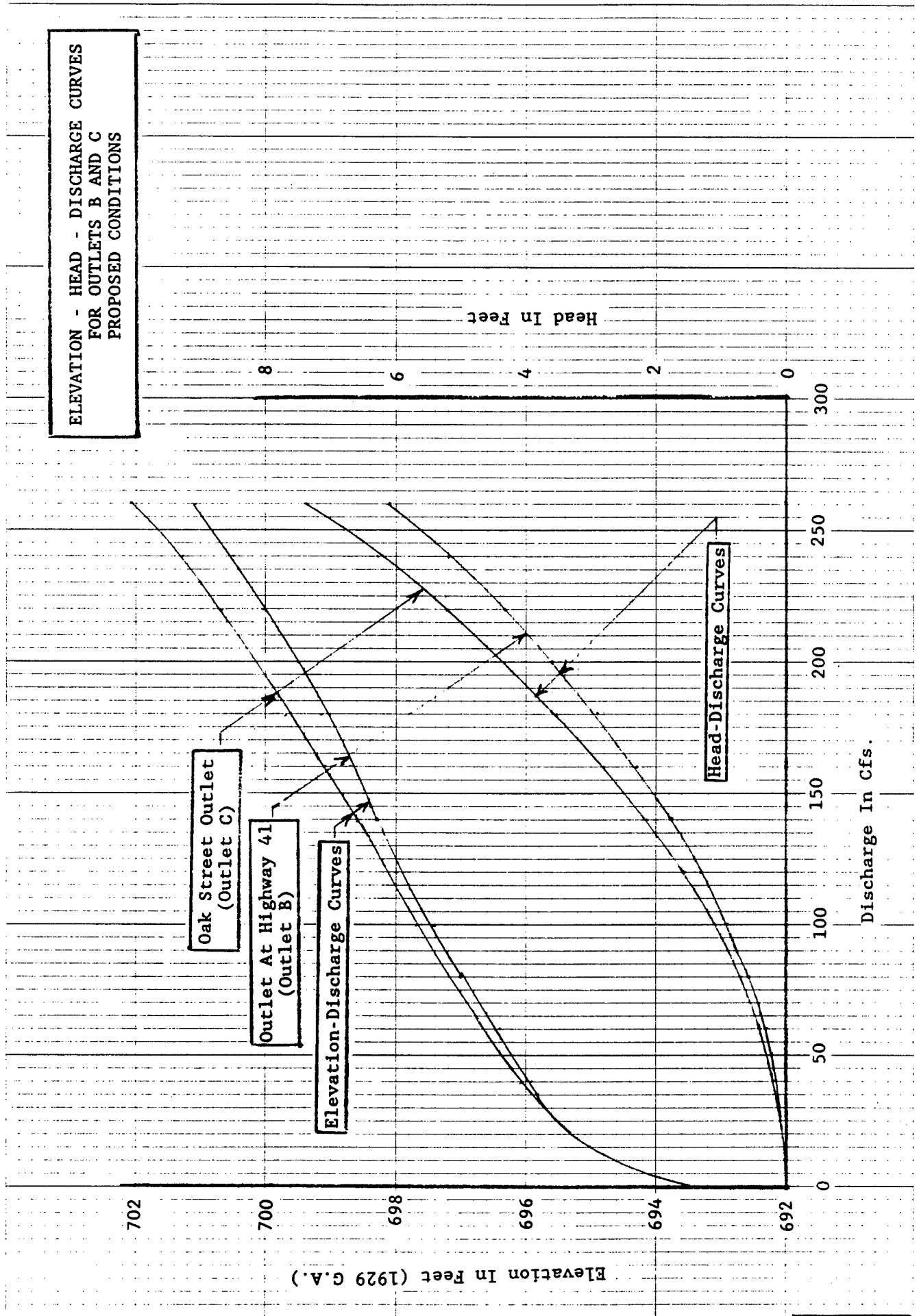
36" RCP at Maple St. - Section 3  
L=105', Inlet Invert El. = 705.0,  
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Section 2 Combined Outflow

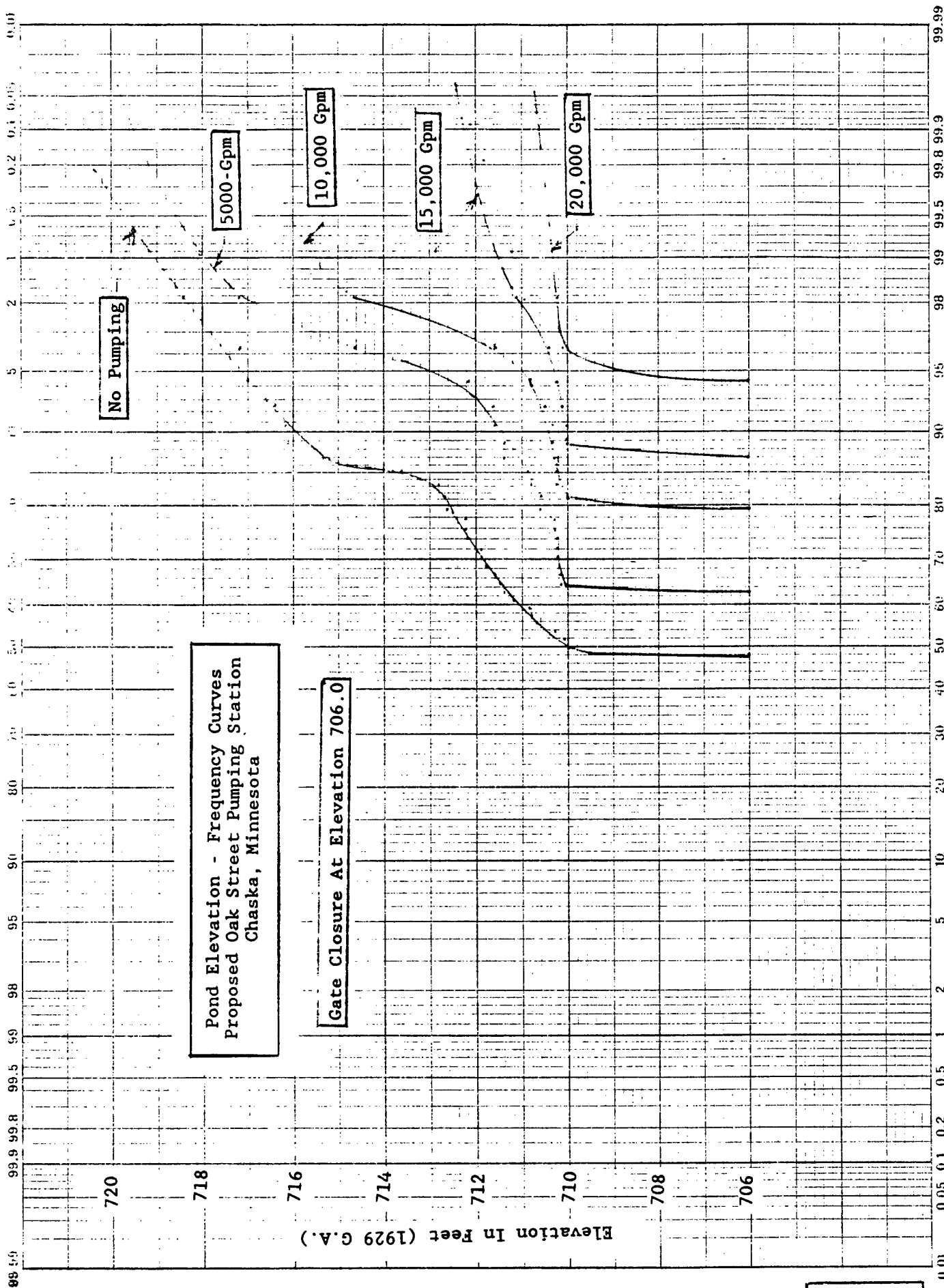
Section 3 Combined Outflow

ELEVATION - DISCHARGE CURVES  
GRAVITY OUTLETS FROM SECTIONS 2 AND 3  
CHASKA, MINNESOTA  
EXISTING CONDITIONS



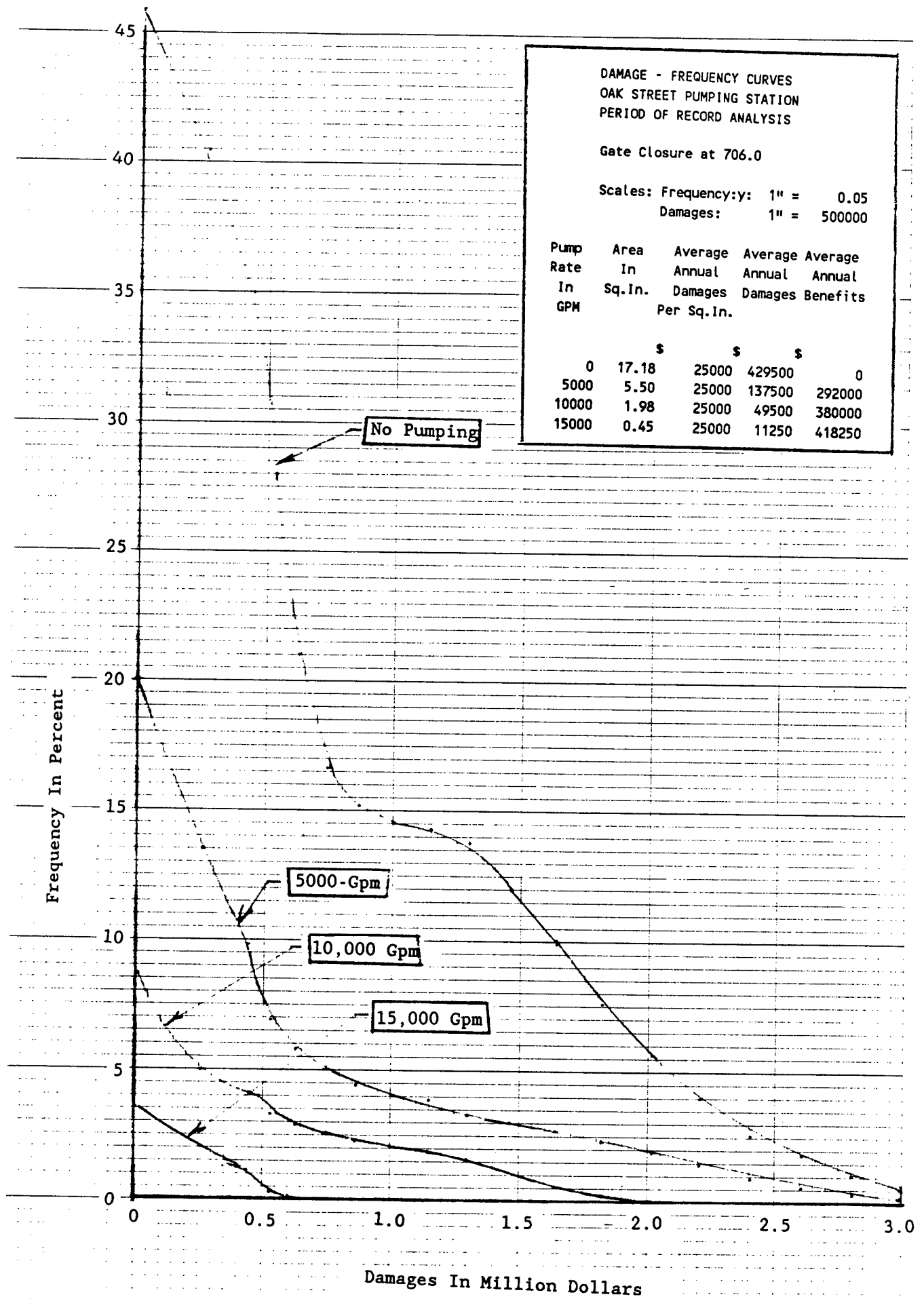


# Frequency In Events Per 100 Years



46 0700

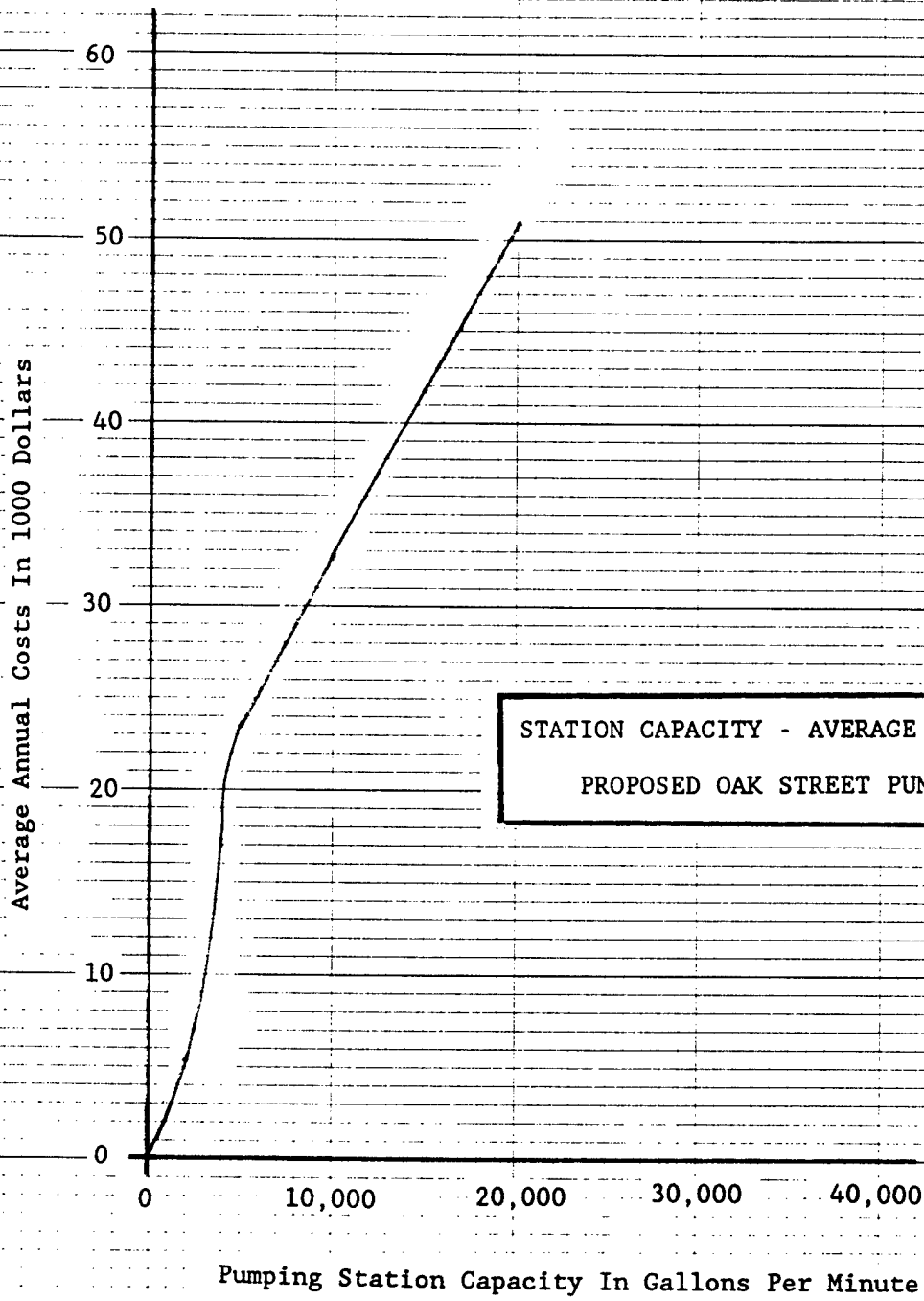
10 X 10 TO THE INCHES  
NEUFEL & ISSER CO. NEW YORK

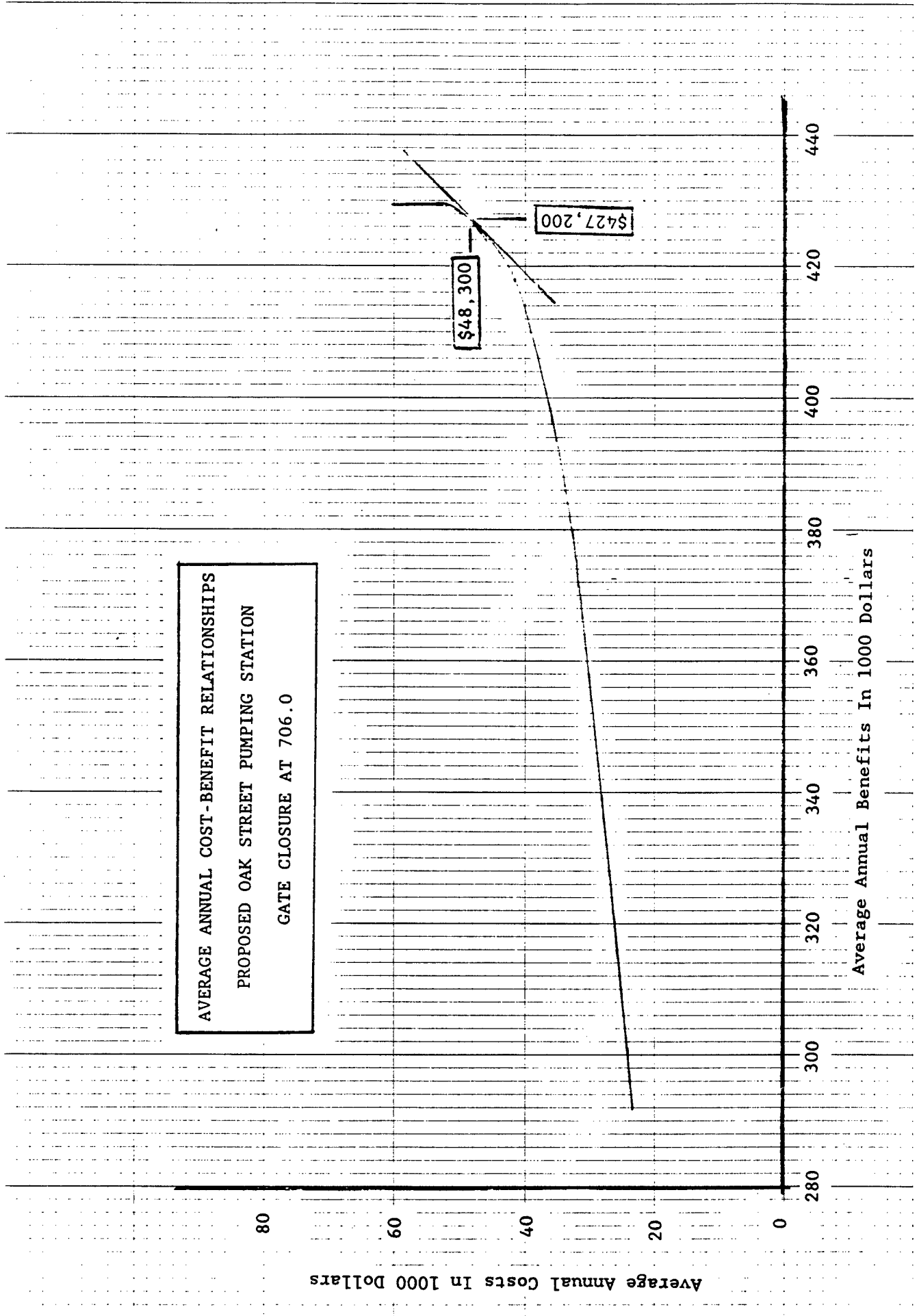




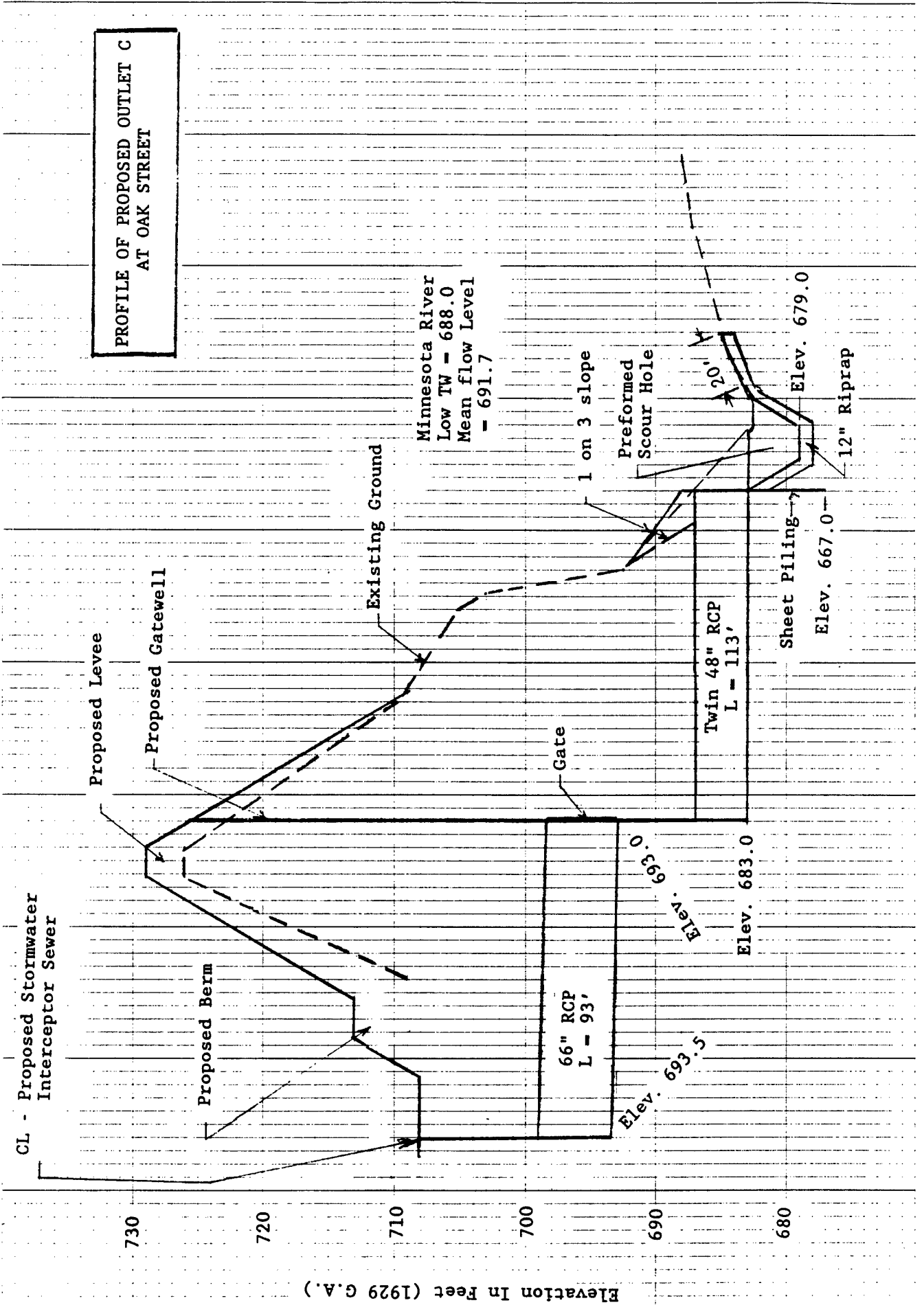
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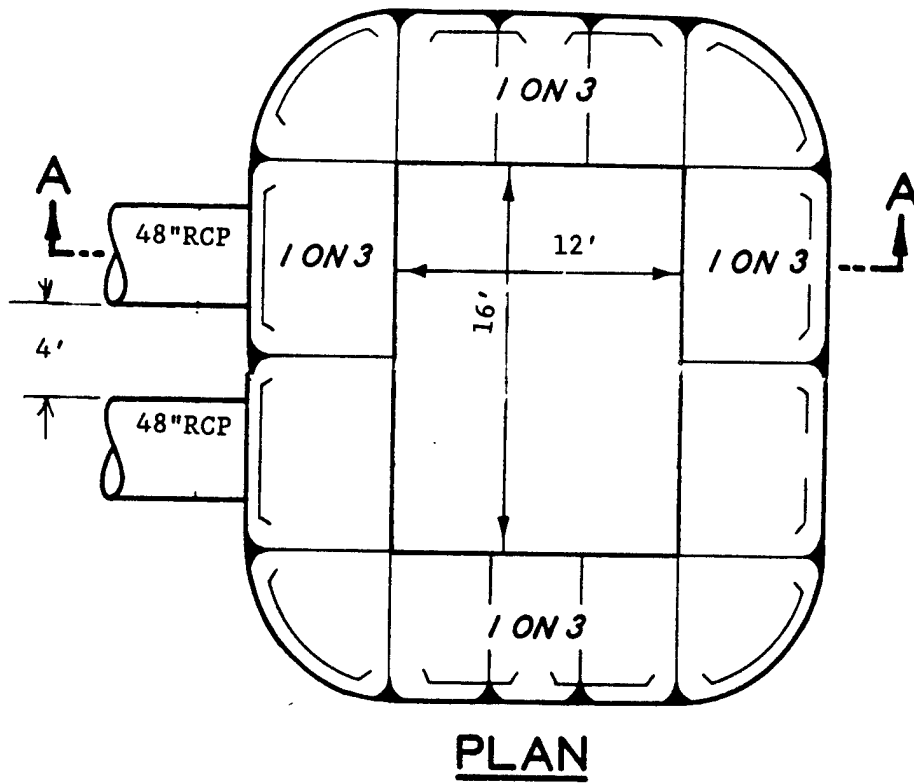
10 X 10 TO THE INCH  
KLUFFEL & LESSER CO. MADE IN U.S.A.



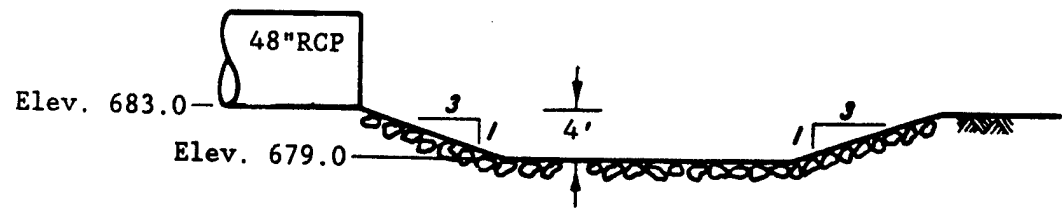








**PLAN**



**SECTION A-A**

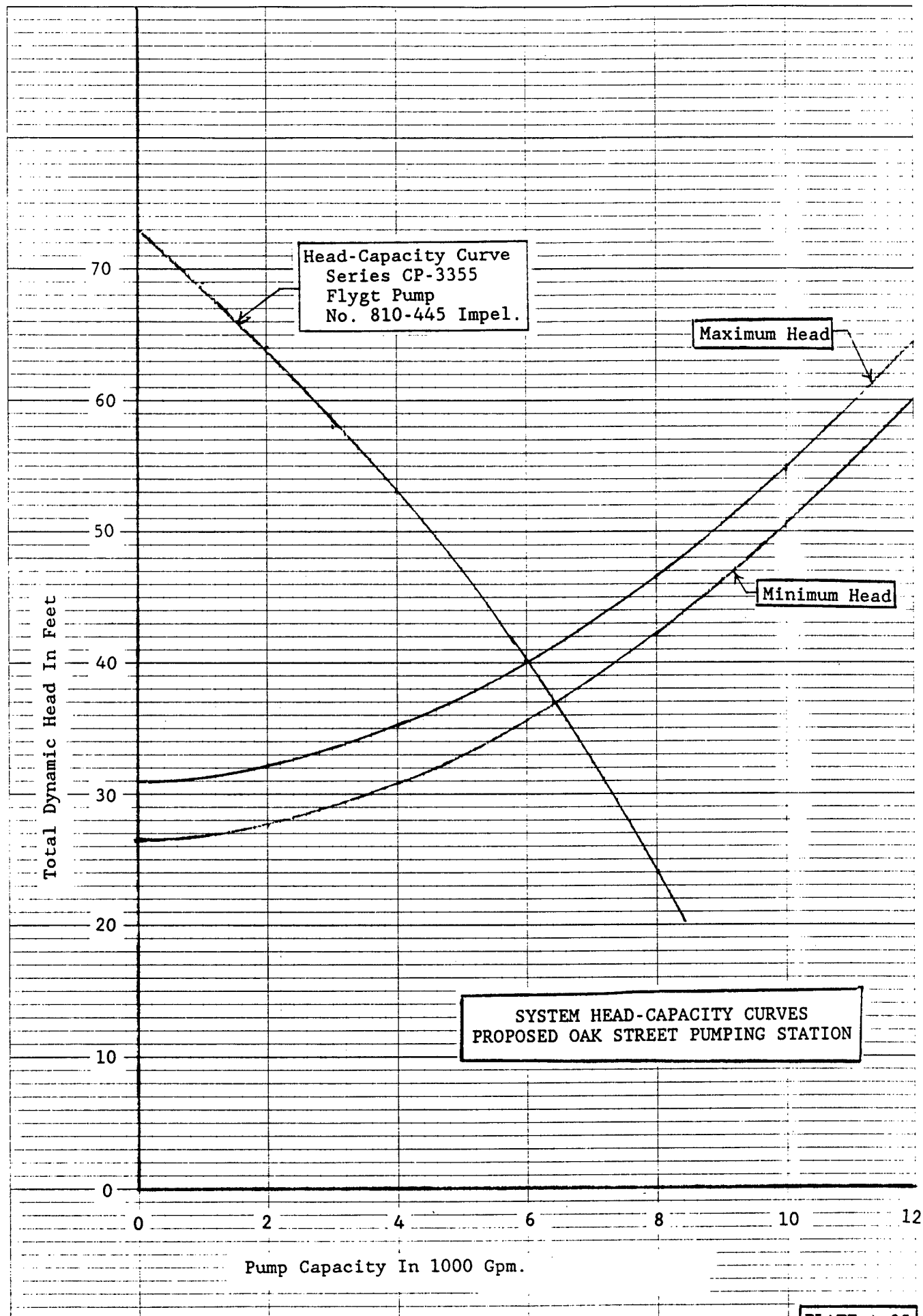
**Required Riprap Gradation**

% Lighter by Weight	Weight Limits	
	Max.	Min.
100	86	35
50	26	17
15	13	5

Thickness - 12 inches

PREFORMED SCOUR HOLE  
OUTLETS B AND C  
PLAN VIEW





APPENDIX B

HYDRAULICS



MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX B

HYDRAULICS

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MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX B

HYDRAULICS

PROJECT DESCRIPTION

1. Stage 4 of the Chaska Flood Control Project consists of the construction of approximately 7000 feet of levee along the Minnesota River and construction of interior flood control (IFC) facilities, which include interceptors and a pump station. Approximately 2000 feet of levee was constructed during Stage 2 of the project (making 9000 total feet of levee for the entire project).

2. The main topic of this appendix is the top of barrier design. Much of the analysis was performed prior to Stage 2 construction in order to determine the final levee heights. The IFC facilities are discussed in appendix A. Previous Studies are discussed in the Feasibility Report, the Limited Reevaluation Report (LRR), and the General Design Memorandum (GDM).

LEVEL OF PROTECTION AND VARIANCES FROM PREVIOUS PLAN

3. The level of protection provided by the levee proposed in this appendix is the 1-percent chance flood. The SPF (as defined by the Minnesota Department of Natural Resources) is contained within the levee freeboard. The level of protection provided by the GDM levee was also the 1-percent chance flood, but freeboard was not sufficient to pass the SPF.

4. During review of the GDM report, the Minnesota Department of Natural Resources (MNDNR) expressed concern that the level of protection did not meet their floodplain regulatory requirements; therefore areas landward of the levee would not be removed from the City's regulatory floodplain. The MNDNR's floodplain management (FPM) requirements for removal of areas from the floodplain are:

a.) The levee must provide at least 3 feet of freeboard above the 1-percent chance flood for FPM (with floodway) conditions.

b.) The top of levee must equal or exceed the elevation of the design SPF for FPM (with floodway) conditions. The design SPF is as defined by the MNDNR and includes the effects of potential bridge plugging.

5. After the GDM was published and before this document was written, the Corps performed further hydraulic analysis and compared the Corps' levee design criteria to the criteria used by the MNDNR in their FPM program. That hydraulic analysis was written into a report titled Hydraulic Evaluation of the Degree of Protection and State of Minnesota Floodplain

Management Considerations for the Proposed Minnesota River Levees of the Chaska Flood Control Project, (Reference 5) and will be referred to as the HEDP report. The top of levee design reported in this appendix is an update of the HEDP analysis, and includes discussion of that analysis where necessary. The HEDP and FDM analysis revealed that the extra increment in levee height required to meet MNDNR FPM requirements was very small, approximately two-tenths of a foot on the downstream reach of the levee. Therefore, the levee was raised to meet the MNDNR's requirements.

6. The MNDNR has reviewed the top of levee design presented in this appendix. A letter dated June 6, 1989 from the MNDNR to the Corps (Reference 6) stated "...the increases in levee height that are proposed will insure that the proposed project remains compliant with the State of Minnesota Floodplain Management regulations."

#### WATER SURFACE PROFILE COMPUTATIONS

7. Water surface profiles for the Minnesota River were computed using an updated HEC-2 computer model of the Lower Minnesota River, originally developed by the United States Geological Survey (USGS) in cooperation with the MNDNR and the Lower Minnesota River Watershed District in 1973. The original model was used to determine flood plain areas of the Lower Minnesota River. The model reach extended from the confluence of the Minnesota River with the Mississippi River upstream through the city of Chaska. This basic model was updated during the LRR analysis, the HEDP report, and this FDM analysis. Cross section locations in the Chaska vicinity are shown on Plate B-1. A typical cross section is shown on Plate B-2.

8. The hydraulic analysis focused on updating the HEDP HEC-2 model. Pertinent corrections to the HEC-2 model were made using original survey data obtained from the USGS, as well as bridge data obtained from the Minnesota Department of Transportation (MNDOT). With this data, the following major corrections were made to the model:

- a.) The Cedar Ave. bridge was recoded to represent the new bridge installed since the original model was created.
- b.) The 35W bridge was recoded from a special bridge routine to a normal bridge routine.
- c.) The railroad bridge between Savage and Bloomington was converted from a special bridge routine to a normal bridge routine.
- d.) The abandoned railroad bridge at Chaska was converted from a special bridge routine to a normal bridge routine.
- e.) Pedestrian guard rails at the abandoned railroad bridge at Chaska were added.

TABLE 1  
WATER SURFACE PROFILE ELEVATIONS  
TOP OF LEVEE DESIGN ELEVATIONS  
MINNESOTA RIVER AT CHASKA

ALL ELEVATIONS ARE IN NGVD 1929								
SECNO	ELMIN	MNDNR FPM 1-PCT CWSEL	MNDNR FPM SPF CWSEL	USACE GDM 1-PCT CWSEL	USACE FDM 1-PCT CWSEL	USACE FDM SPF CWSEL	153000 CFS LEVEE OVERTOP CWSEL	USACE DESIGN TOP OF LEVEE ELEV
70	685.00	723.55	727.47	724.20	724.34	728.32	727.45	727.5
71	659.70	723.64	727.55	724.20	724.44	728.41	727.55	727.9
72.3	672.40	723.58	727.49		724.38	728.36	727.50	
72.4	672.40	723.55	727.48		724.37	728.36	727.49	
72.8	672.40	723.60	727.52		724.42	728.41	727.54	
72.9	672.40	723.84	727.60		724.60	728.41	727.60	
73	669.90	724.36	728.15	724.80	725.06	728.89	728.08	728.5
74	685.30	724.55	728.36	724.90	725.26	729.11	728.29	728.7
75	674.90	724.66	728.49	725.10	725.37	729.24	728.42	728.9
75.4	674.90	724.67	728.49		725.38	729.25	728.42	
76	674.30	724.64	728.47		725.36	729.23	728.40	
76.2	674.30	724.65	728.47		725.37	729.23	728.41	
76.8	674.30	724.83	728.66		725.52	729.39	728.57	
77	680.10	724.84	728.67	725.30	725.53	729.40	728.58	729.1
78	686.60	724.94	728.77	725.40	725.63	729.51	728.68	729.2

NOTE: The discharges and the FN values (J2.6 of the HEC-2 model) are shown below.

Flood Event	Design and FPM Discharge	Design FN	FPM FN
1-PCT	115,000 cfs	1.1	1.0
SPF	165,000 cfs	1.0	0.91

f.) The Minnesota River levee encroachments at Chaska were added.

9. Correction "d" had the largest impact on the water surface profiles at Chaska, increasing the design 1-percent chance water surface profile approximately 0.4 feet and the design SPF profile approximately 0.2 feet above the profiles computed for the HEDP report. The other corrections

caused an approximate 0.1 foot accumulative increase in the water surface profiles.

10. A table of water surface profiles for the 1-percent chance flood and SPF in the city of Chaska are shown on Table 1. The table shows water surface profile elevations for both Corps' criteria and the MNDNR' criteria. Plotted water surface profiles are shown on Plates B-3 and B-4.

#### STARTING WATER SURFACE ELEVATIONS

11. Starting water surface elevations for the Minnesota River at its junction with the Mississippi River are based on the elevation-discharge rating curve for the Mississippi River shown on Plate B-5. The curves were developed from data from the October 1972 Mississippi River Flood Plain Information (FPI) report and the MDNR's subsequent floodway analysis.

12. Starting water surface elevations were determined from this rating curve by assuming that low exceedance frequency events occur coincidentally on both the Minnesota and Mississippi Rivers. For example, the starting water surface elevation for the 1-percent chance flood on the Minnesota River is determined from backwater computations for the 1-percent chance flood on the Mississippi River. The starting water surface elevation for the SPF discharge on the Minnesota River (which corresponds to a 0.27-percent chance flood on the Mississippi), is determined from backwater computations for a 194,000 CFS discharge on the Mississippi (the discharge for a 0.27-percent chance event on the Mississippi).

#### CHANNEL ROUGHNESS DETERMINATION

13. Manning's "n" values for existing conditions were determined by the USGS during the Lower Minnesota Flood Plain study of 1973. This original HEC-2 study model was calibrated using high-water mark data from the 1969 flood, which is the second largest flood of record and approximates a 2-percent chance exceedance frequency event in the city of Chaska. Manning's "n" values for this original study were not varied with discharge. However, during the HEDP evaluation, "n" values were adjusted for discharge according to the percentages shown on the FN curve on Plate B-6 (FN is variable J2.6 of the HEC-2 model). This curve was developed from observed "n" value discharge relationships for the 1965 flood (113,400 cfs), 1969 flood (84,600 cfs), and 1984 flood (43,800 cfs) for the Minnesota River in Scott County, Minnesota.

14. The existing conditions FN curve was increased by ten percent to establish the design (future) conditions FN curve. This latter curve was used to adjust the original USGS "n" values for the proposed design water surface profile computations.

#### TOP OF BARRIER DESIGN AND FREEBOARD

15. The proposed top of levee elevations are listed in Table 1 and shown on Plate B-7. These elevations were determined by adding 3 feet of freeboard to the Corps' design 1-percent chance flood profile and providing an additional increment of freeboard as described in Reference 4. This "superiority freeboard" assures that overtopping occurs in the least critical area, which is the downstream end of the levee. An additional two-tenths of a foot were added at the the very downstream end of the levee to satisfy MNDNR requirements as listed in paragraph 2. Table 2 gives the computation procedure for computing the top of levee elevations. Table 3 compares the top of levee elevations from the LRR, GDM, and the FDM.

#### ICE AND DEBRIS

16. The effects of ice and debris plugging at the bridges were determined to have a negligible effect on the water surface profiles. Therefore plugging was not assumed in the top of levee design.

#### PROFILE SENSITIVITY

17. Water surface profiles are stable and are not highly sensitive vertically to changes or modifications of the floodplain. (However, a small change in the vertical will backwater for several thousand feet upstream, but is not the critical element in the sensitivity analysis.) During the analysis of water surface profiles, modifications to the abandoned railroad embankment which crosses the floodplain were examined as a means of reducing the levee heights. Water surface profiles were computed with the embankment (which is currently a park trail) lowered to an elevation equivalent to the surrounding floodplain. The effect on the computed profiles was negligible. Other corrections and/or tests made to the model as described in sections 3 and 7 of this appendix indicate that the profiles are not highly sensitive in the vertical direction.

#### CHANNEL STABILITY

18. Examination of photographs going back 25 years indicates the river channel in the Chaska vicinity is relatively stable, and there is very little potential of significant channel meandering occurring in the near future. Channel erosion occurring at the Hwy 41 bridge is addressed in the EROSION PROTECTION section of this appendix. Channel aggradation has been observed in the Mankato area, upstream of Chaska. However, channel aggradation in the Chaska area will have little effect on water surface profiles of the larger events because of the wide floodplain in the area.

TABLE 2

TOP OF LEVEE DESIGN COMPUTATIONS  
MINNESOTA RIVER AT CHASKA

ALL ELEVATIONS ARE IN NGVD 1929							
	1	2	3	4	5	6	
		USACE	1-PCT	153000	LEVEE		USACE
		FDM	CWSEL	CFS	ELEV	MNDNR	DESIGN
		1-PCT	PLUS	OVERTOP	WITH	FPM	TOP OF
SECNO	XLCH	1-PCT	3 FEET	CWSEL	SUPER-	SPF	LEVEE
	FEET	CWSEL			RIORITY	CWSEL	ELEV
70	3110	724.34	727.34	727.45	727.3	727.47	727.5
71	970	724.44	727.44	727.55	727.9	727.55	727.9
72.3	70	724.38	727.38	727.50		727.49	
72.4	5	724.37	727.37	727.49		727.48	
72.8	30	724.42	727.42	727.54		727.52	
72.9	5	724.60	727.60	727.60		727.60	
73	40	725.06	728.06	728.08	728.5	728.15	728.5
74	3090	725.26	728.26	728.29	728.7	728.36	728.7
75	1450	725.37	728.37	728.42	728.9	728.49	728.9
75.4	52	725.38	728.38	728.42		728.49	
76	10	725.36	728.36	728.40		728.47	
76.2	38	725.37	728.37	728.41		728.47	
76.8	10	725.52	728.52	728.57		728.66	
77	50	725.53	728.53	728.58	729.1	728.67	729.1
78	4120	725.63	728.63	728.77	729.2	728.68	729.2

NOTE: Column 4 would normally be the Corps' recommended design elevation for top of levee. However, because of the MNDNR flood plain regulation requirements, column 6 contains the recommended design elevations. Note the only difference between the levee elevations in columns 4 and 6 is that 0.2 feet were added to the levee at secno 70 to meet MNDNR requirements.

#### LEVEE CLOSURES

19. A levee closure will be required at the intersection of the levee with Highway 41. The elevation of the top of road at this intersection is approximately 725.4 feet. The maximum closure height is approximately 3.7 feet, which is essentially in the levee freeboard (freeboard is 3.6 feet at



TABLE 3  
COMPARISON OF TOP OF LEVEE DESIGN ELEVATIONS  
LRR, GDM, AND FDM

---

ALL ELEVATIONS ARE IN NGVD 1929

---

SECNO	USGS R-MILE	LRR TOP OF LEVEE ELEV	GDM TOP OF LEVEE ELEV	FDM TOP OF LEVEE ELEV	FLOOD PROFILE FOR Q = 153000	SUPERIORITY FREEBOARD FEET	TOTAL FREE- BOARD FEET
70	27.86	727.38	727.50	727.5	727.45	0.0	3.0
71	28.04	727.48	727.50	727.9	727.55	0.3	3.3
72.3	28.06	bridge			727.50		
72.4	28.06	bridge			727.49		
72.8	28.06	bridge			727.54		
72.9	28.06	bridge			727.60		
73	28.07	728.38	727.50	728.5	728.08	0.4	3.4
74	28.66	728.56	728.00	728.7	728.29	0.4	3.4
75	28.93	728.69	728.00	728.9	728.42	0.5	3.5
75.4	28.94	bridge			728.42		
76	28.94	bridge			728.40		
76.2	28.95	bridge			728.41		
76.8	28.95	bridge			728.57		
77	28.96	728.91	728.50	729.1	728.58	0.5	3.5
78	29.74	729.02	729.00	729.2	728.68	0.5	3.5

---

the closure). A stop log closure will not be required because the closure is essentially in the freeboard range and ample time should be available to construct a sandbag closure. During the 1965 flood of record, the river rose at a relatively rapid rate of 0.2-0.3 foot per hour. Assuming a similar rate of rise and sandbag mobilization begins when the river is 3 feet from the closure, 15 hours would be available to construct the first foot of closure. For each foot of closure constructed, an additional 5 hours of time would be available to construct the next foot. The 1969 flood did not rise this rapidly; therefore the 1965 flood rate of rise could be considered a possible yet conservative scenario for future floods.

20. The levee closure will only be required for events that approach the 1-percent chance flood. Therefore the frequency of closure will be quite rare. Neither the 1965 or 1969 floods reached the critical elevation of the closure of 725.4.

#### LEVEE OPENING AT EAST CREEK

21. The East Creek Diversion design (Stage 3 of the Chaska Flood Control Project) is not final at this writing. The diversion channel design will affect the size of hydraulic structure required to pass East Creek flows through the levee and into the Minnesota River. Therefore, the levee will be left open at the East Creek intersection. The required structure will be designed and constructed during Stage 3 FDM analysis.

22. The recommended opening in the levee allows 30 feet between the toe of the levee and the left and right channel banks of the creek. The levee opening is sloped back at a 3H:1V side slope from the toe to top of levee. See Plate B-8 for a sketch of the opening.

#### EROSION PROTECTION

23. Erosion is currently occurring on the left bank immediately downstream of the Highway 41 bridge. The river takes a sharp bend upstream of the bridge, causing higher velocities and eddies to impinge upon this bank. The toe of the levee will project somewhat farther into the main channel, requiring armoring with riprap both upstream and downstream of the bridge.

24. The riprap computations were based on HL-88-4 and revealed that only a 12 inch layer thickness was required. However, an 18 inch layer is recommended for the following reasons:

- a.) The sharp bend upstream of the bridge causing ice and debris to impinge on the bank.
- b.) The presence of the bridge at the location of the sharp channel bend creating undefinable flow patterns.
- c.) The riprapped area will be along a public walking trail creating easy access for vandalism.

The riprap gradation and other pertinent data is shown on Table 4. Maximum velocities in the main channel occur at approximately 50,000 cfs; therefore this discharge was used for the riprap design. The area of the left bank to be riprapped extends from approximately 100 feet upstream of the bridge to approximately 300 feet downstream of the bridge. Because the bridge may create erosive flow patterns for flows higher than 50,000 cfs, the riprap will be carried to the design flood elevation of 725.4. The layer thickness will be increased by 50 percent where underwater placement will be required.

TABLE 4

RIPRAP DATA  
MINNESOTA RIVER AT CHASKA

DESIGN DATA

-----  
Riprap design discharge = 50,000 CFS  
Average channel velocity = 3.6 FPS  
Channel design velocity = 5.4 FPS (avg. vel. X 1.5)  
Channel velocity at toe = 10.9 FPS

RIPRAP GRADATION

-----  
d100(max) = 18 in.  
d30(min) = 0.73 ft.  
d90(min) = 1.06 ft.  
layer thickness = 18 in.  
(increase by 50% for underwater placement)  
top of riprap elevation = 725.4 ft.

PCT LIGHTER BY WEIGHT	LIMITS OF STONE WEIGHT, LBS	
	MAX	MIN
100	292	117
50	86	58
15	43	18

PRE- AND POST-PROJECT CONDITIONS

25. Construction of the flood barrier as proposed in this report will have no effect on river conditions either upstream or downstream of the project. The levee will not impact water surface profiles, velocities, or channel aggradation when compared to pre-project conditions. No other future impacts are foreseen.

OPERATION AND MAINTENANCE

26. Periodic inspections and warranted repairs of the levee will be required to insure its structural integrity and functionability during the life of the project. The sandbag closure will be required during events approaching the 1-percent chance flood. The levee opening at the East Creek intersection will prevent the levee system from being completely

functional until Stage 3 construction completes that portion of the levee. The city may want to develop a contingency plan for emergency closure and control of interior flooding for floods on the river during the interim period between Stage 4 and Stage 3 construction.

## REFERENCES

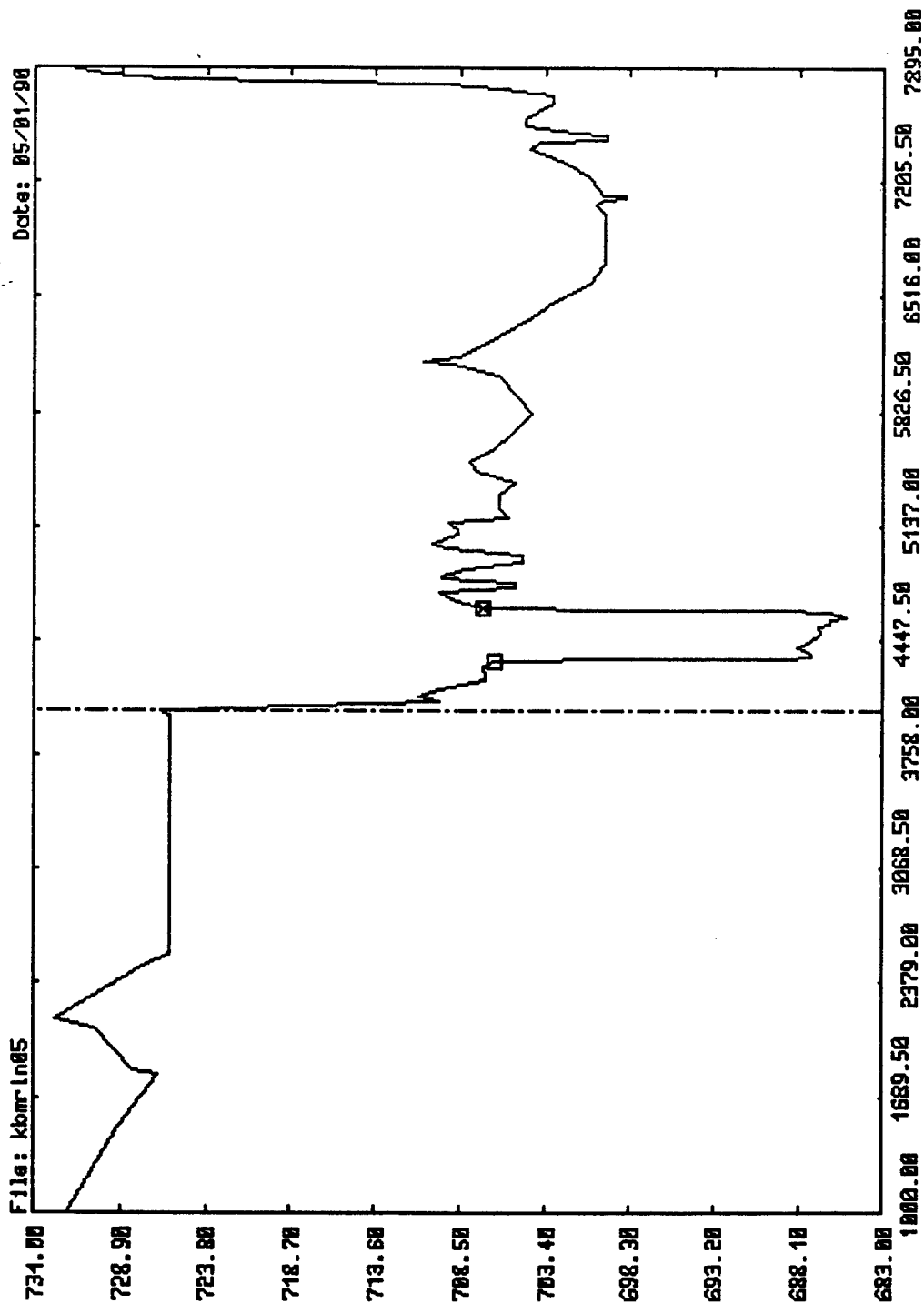
1. Corps of Engineers. 1973. Feasibility Report for Flood Control. Minnesota River at Chaska, Minnesota. U.S. Army Corps of Engineers, St. Paul District, Minnesota.
2. Corps of Engineers. 1982. Limited Reevaluation Report and Final Supplement to the Final Environmental Impact Statement for Flood Control and Related Purposes. Minnesota River at Chaska, Minnesota. U.S. Army Corps of Engineers, St. Paul District, Minnesota.
3. Corps of Engineers. 1984. General Design Memorandum and Draft Supplement II to the Final Environmental Impact Statement. Minnesota River at Chaska, Minnesota. U.S. Army Corps of Engineers, St. Paul District, Minnesota.
4. Corps of Engineers. August 22, 1986. ETL 1110-2-299, Overtopping of Flood Control Levees and Floodwalls. U.S. Army Corps of Engineers, Washington, DC.
5. Corps of Engineers. 1987. Hydraulic Evaluation of the Degree of Protection and State of Minnesota Floodplain Management Considerations for the Proposed Minnesota River Levees of the Chaska Flood Control Project. Minnesota River at Chaska, Minnesota. U.S. Army Corps of Engineers, St. Paul District, Minnesota.
6. Minnesota Department of Natural Resources. June 6, 1989. Letter from Ronald D. Harnack, MNDNR, to Robert F. Post, USACE.

MINNESOTA RIVER AT  
CHASKA, MINNESOTA  
FLOOD CONTROL PROJECT  
FEATURE DESIGN MEMORANDUM  
HYDRAULICS APPENDIX

Minnesota River Cross  
Section Locations



# EVALUATION OF LEVEL OF PROTECTION FOR THE CHASKA FLOOD CONTROL PROJECT



STATION IN FEET

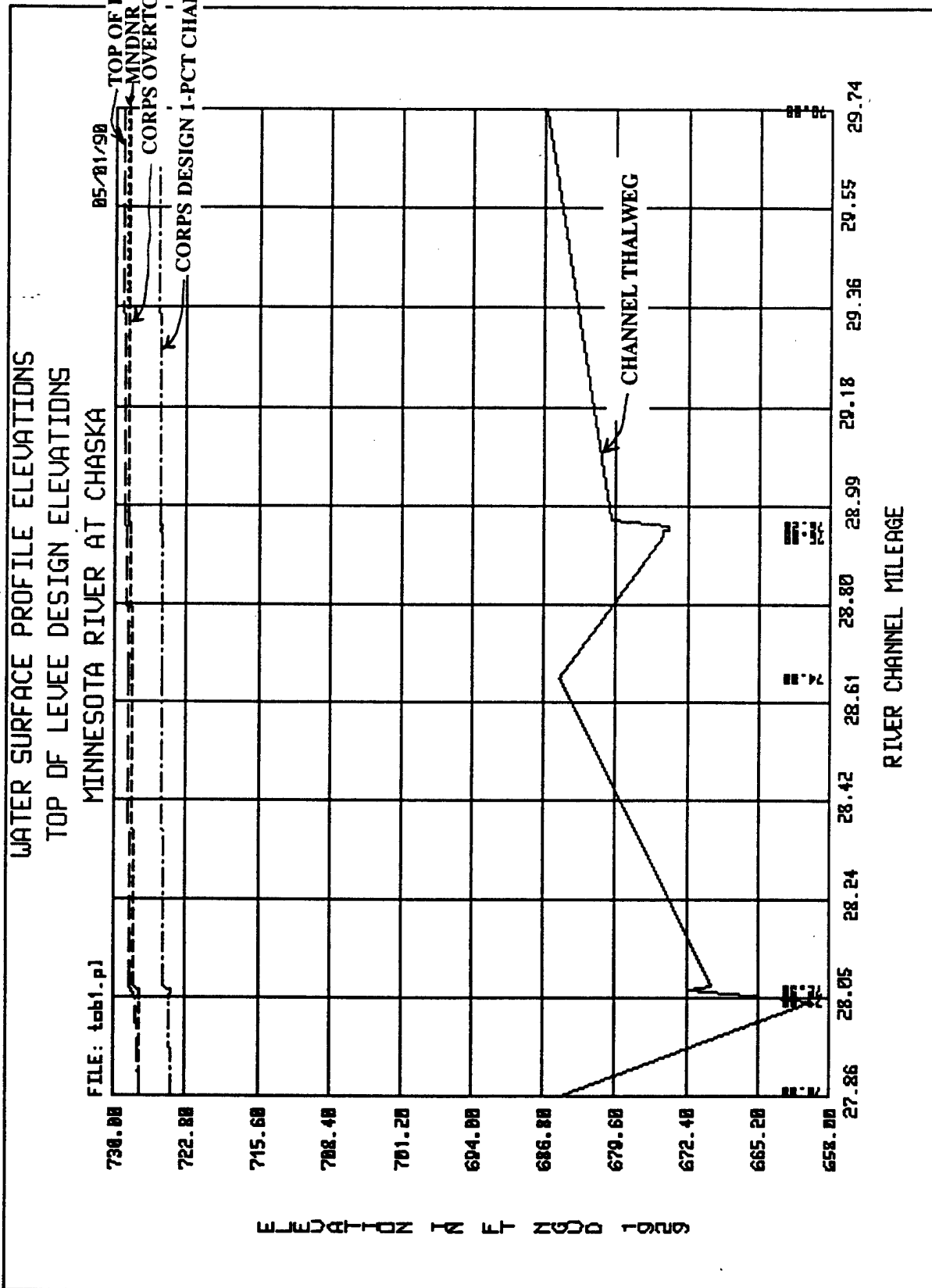
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STENCR-7895.00

MINNESOTA RIVER AT  
CHASKA, MINNESOTA  
FLOOD CONTROL PROJECT

FEATURE DESIGN MEMORANDUM  
HYDRAULICS APPENDIX

Minnesota River  
Typical Cross Section

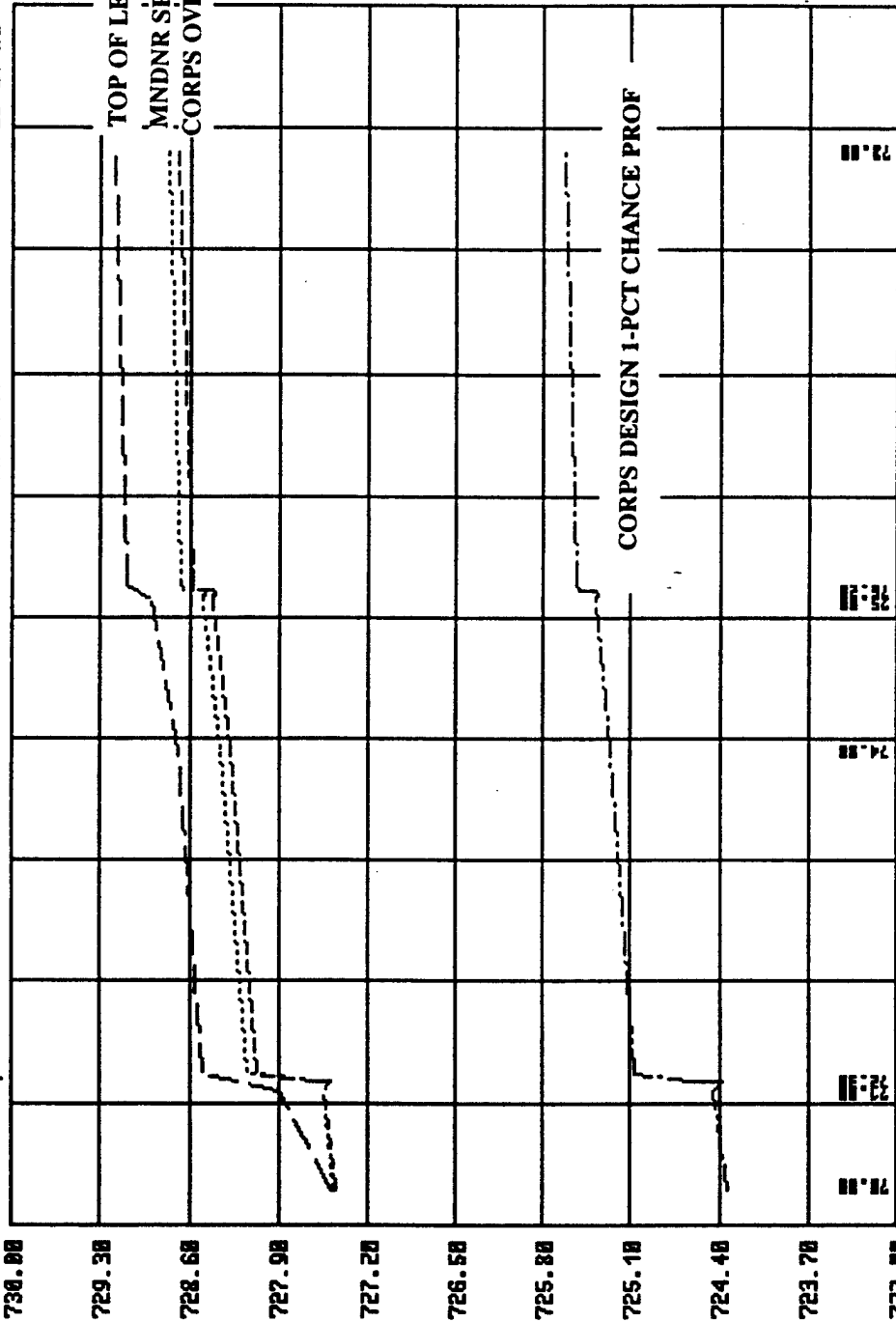




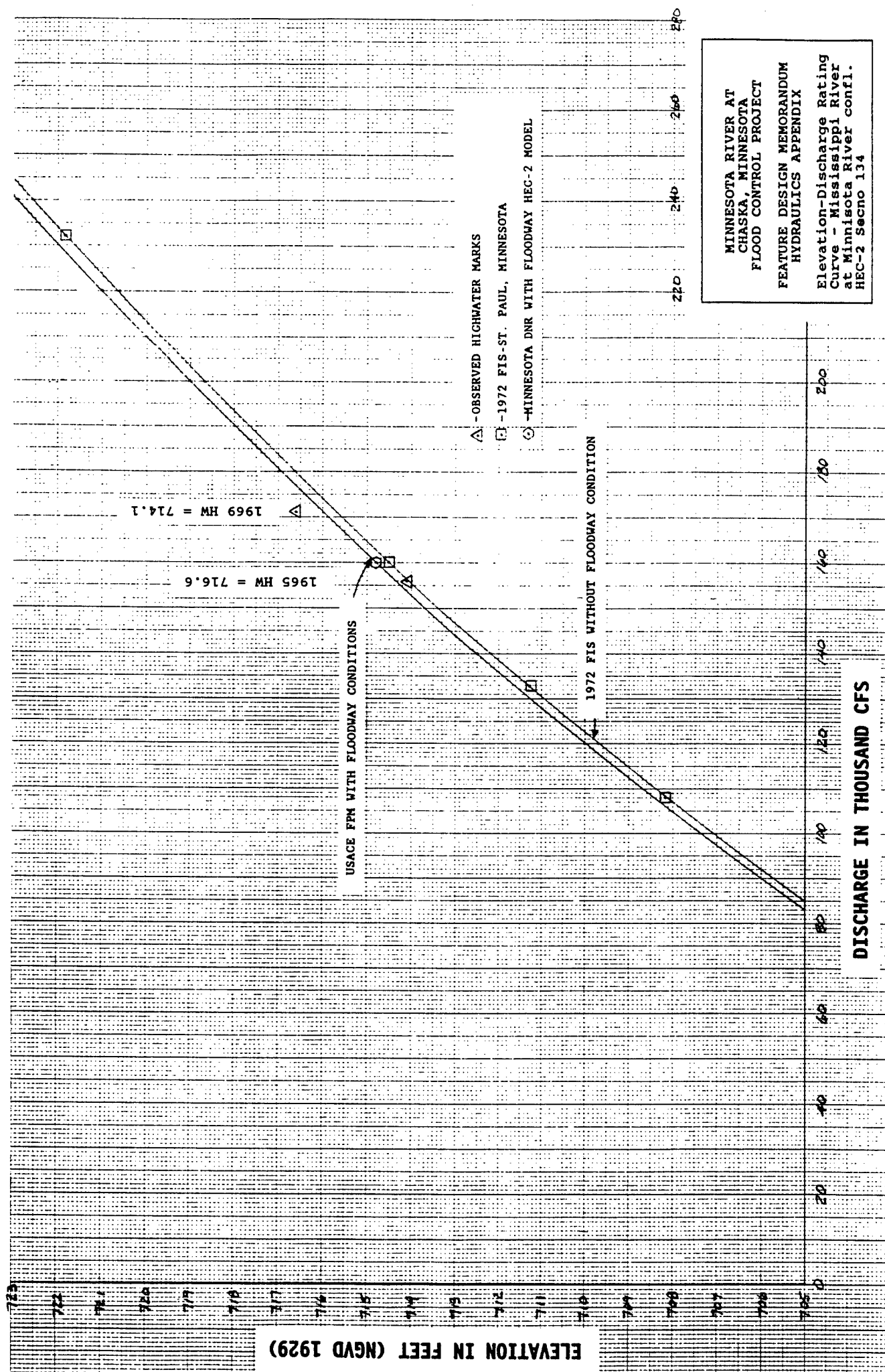
# WATER SURFACE PROFILE ELEVATIONS TOP OF LEVEE DESIGN ELEVATIONS MINNESOTA RIVER AT CHASKA

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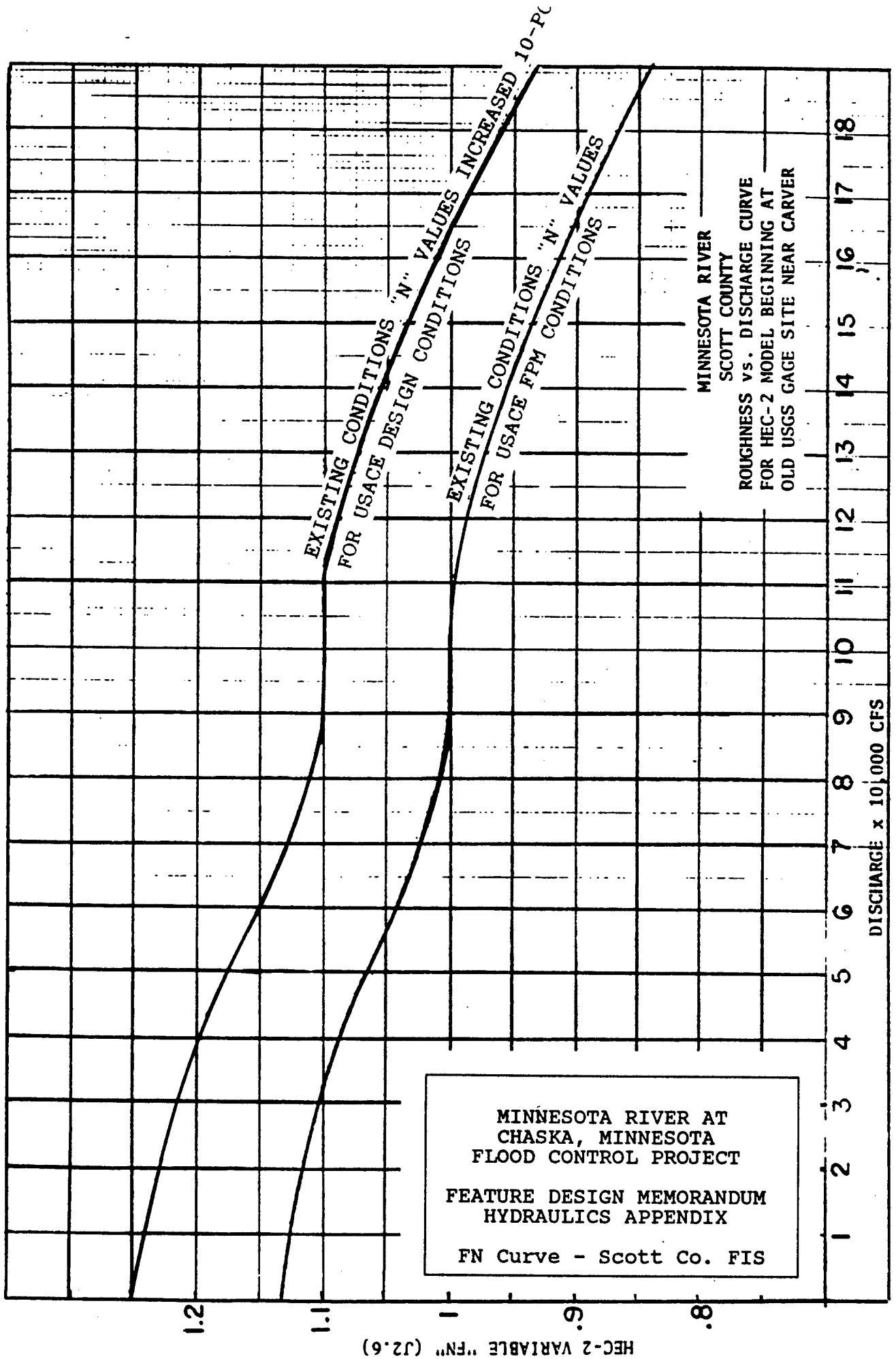
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RIVER CHANNEL MILEAGE



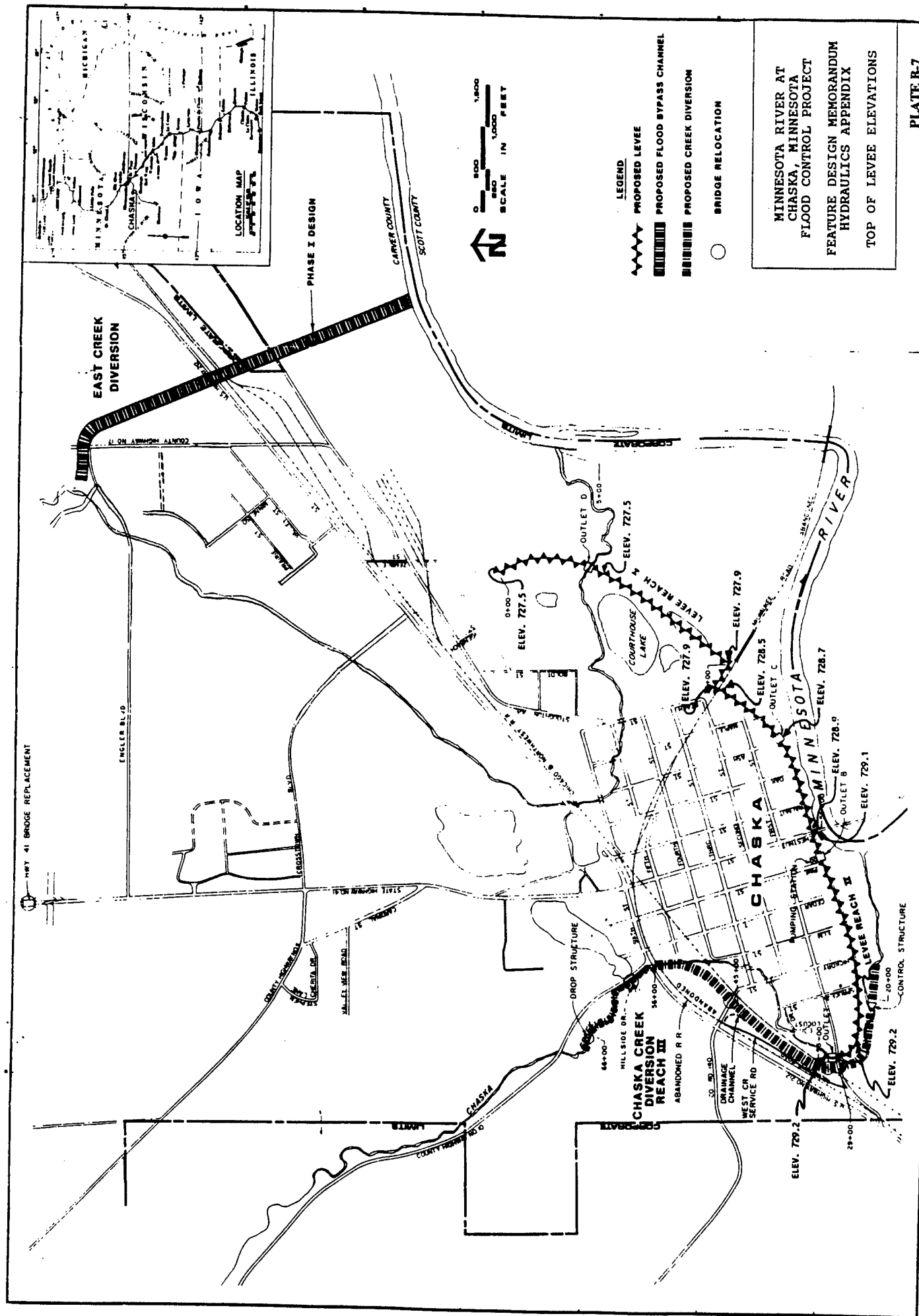
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CHASKA, MINNESOTA  
FLOOD CONTROL PROJECT  
FEATURE DESIGN MEMORANDUM  
HYDRAULICS APPENDIX  
Elevation-Discharge Rating  
Curve - Mississippi River  
at Minnesota River confluence  
HEC-2 Secno 134



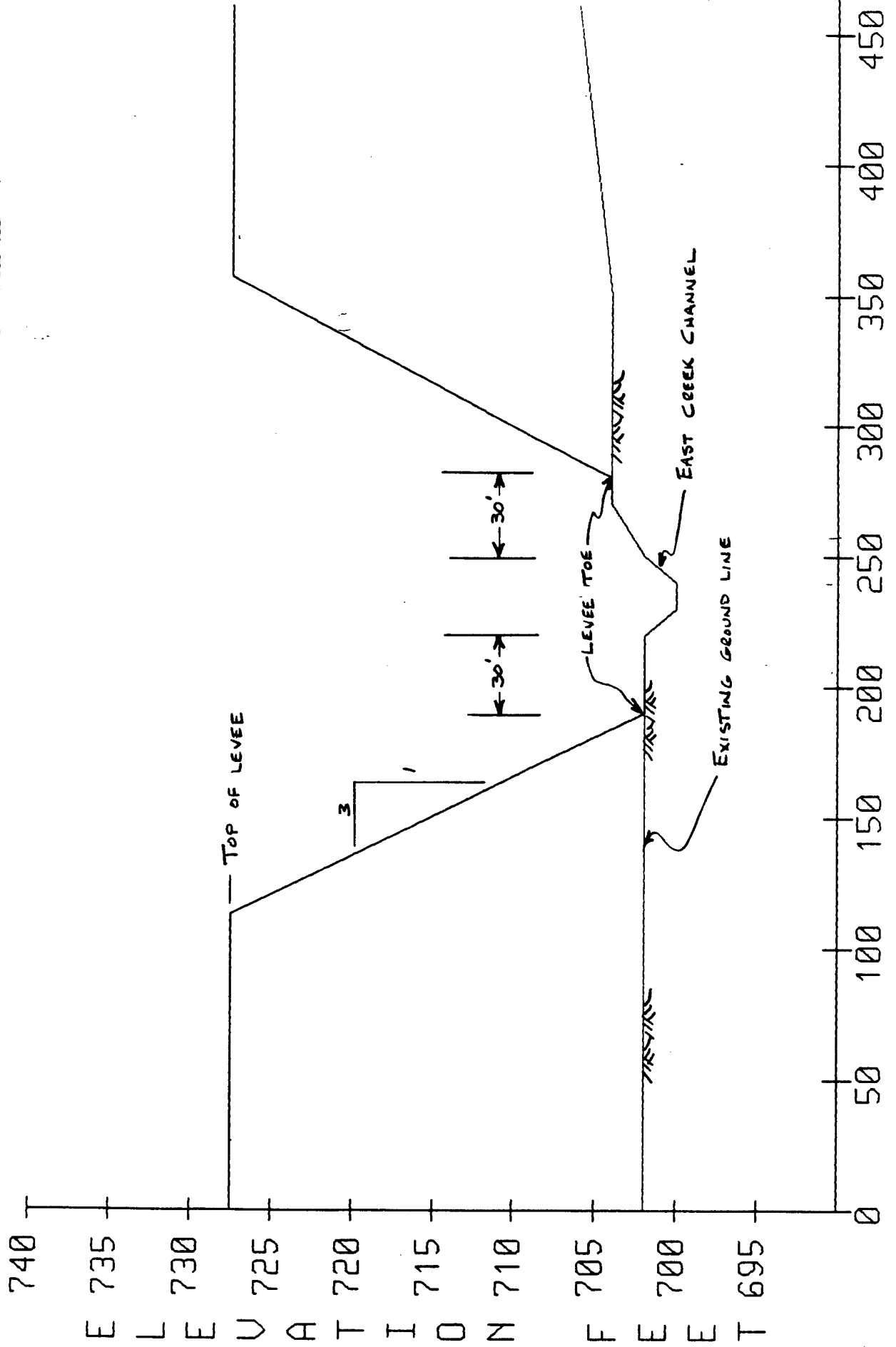
MINNESOTA RIVER AT  
CHASKA, MINNESOTA  
FLOOD CONTROL PROJECT  
FEATURE DESIGN MEMORANDUM  
HYDRAULICS APPENDIX  
FN Curve - Scott Co. FIS

MINNESOTA RIVER  
SCOTT COUNTY  
ROUGHNESS vs. DISCHARGE CURVE  
FOR HEC-2 MODEL BEGINNING AT  
OLD USGS GAGE SITE NEAR CARVER

HEC-2 VARIABLE "FN" (J2.6)



# LEVEE OPENING AT EAST CREEK



DISTANCE, FEET

APPENDIX C

GEOTECHNICAL DESIGN

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX C

GEOTECHNICAL DESIGN

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## TOPOGRAPHY

1. The portion of the city of Chaska, Minnesota, where the proposed flood control improvements would be located is within the Minnesota River Valley. The valley trends northeast and is approximately 2.5 miles wide in this reach. The floodplain lies at an approximate elevation of 705, averages 1 mile in width, and is characterized by extensive marshy areas and lakes. Alluvial and bedrock terraces rise above the floodplain and form regionally prominent benches at elevations of 750 and 800. Most of the developed portion of Chaska is situated between elevations of 710 and 730, at the upstream limit of a terrace that trends northeast along the base of the valley wall. The river valley walls rise sharply above the floodplain and terraces to form a bluff that grades into a hummocky, poorly-drained regional highland at an elevation of 850 on the north side of the valley, and at an elevation of 900 on the south side of the valley.

2. Chaska Creek emerges from the regional highland in a deep, steep-walled valley on the northwest side of Chaska and flows in a shallow channel around the western and southern edges of the city to the Minnesota River. East Creek emerges from a similar but smaller valley onto a large terrace about 1.5 miles northeast of Chaska. The creek flows southwesterly across the terrace, cuts through the northeast corner of Chaska, and joins the Minnesota River downstream of the city. The normal flow in the two creeks is sustained by groundwater discharging from pervious materials in thick deposits of glacial till that comprise the surrounding regional highlands.

## GEOLOGY

3. The region surrounding the project area was glaciated extensively during the Pleistocene Epoch. Advancing and retreating glaciers laid down thick deposits of unsorted till and outwash sand that today form a hummocky, poorly-drained plain dotted with numerous marshes and small lakes. The glacial drift reaches a thickness of between 200 and 250 feet and lies unconformably on dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations. The large valley of the present Minnesota River was carved by the glacial River Warren, which carried large volumes of water discharging from the now-extinct glacial Lake Agassiz located in western Minnesota and eastern North Dakota. Glacial River Warren cut deeply into bedrock and formed the terraces that are prominent today. As the flows decreased, the valley was filled to its present level with alluvium. Recent borings and historic water well records indicate alluvium approximately 180 feet in thickness. Bedrock elevation is between 530 and 542(NGVD Adj.). The upper bedrock consists of weathered to slightly weathered fine grained, silty, glauconitic sandstone of the Franconia Formation.

## SUBSURFACE INVESTIGATIONS

4. Borings have been taken and laboratory tests have been performed periodically from 1973 to 1989 as the study progressed to the present phase.

5. The 1973 borings were taken to determine the general characteristics of the soils along the entire reach of the project. The 1979 borings were taken to better define the soil profile used for uplift and seepage design along the levee. The 1980 borings were taken to determine soil types used in the existing levees. The 1982 borings were taken east of Courthouse Lake to obtain more information along the proposed levee alignment and to determine the material used to fill the area north of the sewage treatment plant. The 1983 borings were taken to obtain additional subsurface information all along the proposed levee alignment. The 1987 borings were taken to evaluate a VE proposal which would have rerouted Chaska Creek through a conduit under Elm Street. The 1988 borings were taken along one of the proposed alignments of East Chaska Creek. The 1989 borings were taken to better define the characteristics of the pervious zone underlying the site from the sewage treatment plant to Pine Street and to obtain more information on the low area east of Courthouse Lake.

6. Laboratory soil tests performed to date include water content, gradation tests, Atterberg limits, strength and consolidation. The laboratory test data are presented on figures C-1 to C-548.

#### SUBSURFACE PROFILES

7. The project site can be divided into five reaches that have fairly distinct soil profiles. The following table gives the reach number and stationing associated with that particular reach:

Reach No.	Stationing
1	0+00 to 7+50
2	7+50 to 21+00
3	21+00 to 34+00
4	34+00 to 59+50
5	59+50 to the upstream end of the project

8. In Reach 1 the levee foundation consists of firm to stiff silts and clays. There is also a shallow layer of poorly-graded gravel.

9. In Reach 2 the levee foundation consists of highly plastic soft clays overlying much firmer silts and clays. The soft materials have a maximum thickness of about twenty-five feet. The levee alignment in this reach runs near Courthouse Lake, which is an old open pit clay mine that has been filled with water to make a suitable habitat for trout. The bottom of Courthouse Lake is below elevation 650 and the lake bed has a steep slope in this area. Borings taken through the existing levee adjacent to the lake show considerable consolidation of the soft material.

10. Reach 3 is very similar to Reach 2 except that a large amount of uncontrolled fill has been placed northeast of the sewage treatment plant.

11. Borings taken by the county indicate that the area northwest of the sewage treatment plant was used in the past as a landfill.

12. In Reach 4 the boring logs show a deep sand foundation containing thin

impervious layers at various elevations throughout the reach. The sand foundation is generally composed of SP-SM type soils and is overlain by a relatively thin semipervious blanket. From the sewage treatment plant to Pine Street the depth of the pervious material encountered before a continuous cutoff is reached varies considerably. Some borings in this area show intermediate cutoffs at fairly shallow depths. It was reported that the existing levee between stations 35+00 and 41+00 was constructed with a flatter riverward slope than the rest of the levee because debris encountered during construction indicated some of the area may have been used as a landfill.

13. Reach 5 has a levee foundation consisting of a relatively thin semipervious top blanket over a relatively thin pervious zone that extends down to about elevation 686. This overlays a relatively thick layer of impervious clays, silts, and silty sands.

#### PROJECT FEATURES

14. The typical levee section will have 1V to 3H side slopes and a top width of 10 feet. Fill for the levee will be impervious. A bituminous walking trail on an aggregate base will be located on top of the levee. Erosion protection will generally consist of top soil and seeding. The riverward slope of the levee along the Minnesota River will be riprapped. Where required, an inspection trench with a 6 foot bottom width and side slopes no steeper than 1V to 1H will be excavated. Minimum trench depth will be 6 feet for levee heights equal or greater than 6 feet. For levee heights less than 6 feet, the minimum trench depth will be equal to the levee height. The trench will be backfilled with impervious material.

15. From station 0+00 to 7+50 a typical levee section will be used. Erosion protection will consist of top soil and seeding. An inspection trench will be located at the levee centerline.

16. From station 7+50 to 21+00 thirty foot wide berms will be provided on both the river side and land side of the typical levee section. Erosion protection will consist of top soil and seeding. Because of the low strength of the foundation materials the levee will be constructed in two stages. Since the foundation soils consolidate very slowly, "wick" drains will be installed under the levee prism to obtain the required consolidation for second-stage construction in a reasonable time period. A working pad of not less than 2 feet of pervious material will be placed to improve access for construction and to provide a horizontal drainage path for the flow from the "wick" drains. Soil strip drains will be provided along the top of each row of "wick" drains to provide additional horizontal drainage. The berms, which will be constructed of impervious material, are required to provide an adequate surcharge to consolidate the foundation material under the edge of the levee prism and develop sufficient foundation strength for second-stage construction. In order to prevent the pervious working pad from becoming a seepage path through the levee, the riverside berm will be placed on the natural subgrade. First-stage construction will raise the levee to elevation 717. The primary fill (first-stage fill) will need to remain in place for 220 to 330 days before the berms are cut to final grade and the second-stage fill placed. Second-stage construction will raise the levee to

its final height. During the second stage of the construction the berms may be cut to elevation 708. An overbuild of 1 foot will be required on this section of the levee because of anticipated second-stage settlement. An inspection trench will not be required in this reach. Since the design of the East Creek outfall has not been completed an opening will be left in the levee between stations 8+60 and 10+60. The proposed location of the outfall is north of the current creek location and the existing creek will be moved south to allow room to place a surcharge on the proposed outfall location. The surcharge will consolidate the foundation soils at the outfall location. "Wick" drains and the pervious fill working pad should be placed in the East Creek levee opening so the area is ready for fill placement when the outfall is constructed.

17. From station 21+00 to station 34+00 the levee construction will be similar to Reach 2 except that the new section will blanket an existing fill and a land side berm will not be placed. From station 21+00 to station 28+00 the existing uncontrolled fill will be thickly blanketed with impervious fill to provide an acceptable levee. From station 28+00 to station 34+00 the material used in the existing fill appears suitable for levee construction and the thickness of the new "blanketing" fill is reduced. "Wick" drains will be placed from the toe of the existing fill slope to the riverward toe of the new levee. Strip drains which penetrate the impervious riverside berm every 20 feet will provide horizontal drainage for the "wick" drains. These strip drains will be removed after construction. An inspection trench will not be required for this reach. Erosion protection will be provided with top soil and seeding. An existing access road crosses the levee at station 34+00.

18. From station 34+00 to 59+50 the typical levee section will generally be used. From station 36+00 to 43+00 a levee section similar to Reach 3 will be used because of the possibility of soft material existing under the new fill being placed riverward of the existing levee. Relief wells will be required at the landside levee toe from approximately station 36+00 to 59+50. A manhole will be located at each relief well to provide access for maintenance. Flow from the relief wells will be collected by an interceptor pipe running parallel to the levee. A pump station will be located at station 48+00. The depths of the wells will vary depending on the depth of the pervious layer underlying the levee. A 17' wide berm of semipervious material will be placed at the landside toe of the levee. This berm intersects the levee slope at elevation 713. This berm provides frost protection for the relief wells. An inspection trench will run along the landside toe of the levee. Riprap will be placed on the riverside slope of the levee from station 44+50 to 58+00. From station 44+50 to 51+90 the riprap will extend from the riverbed to elevation 710 to protect the levee from being undermined by erosion from the river. From station 51+90 to 58+00 the riprap will extend from the riverbottom to the top of the levee to protect the levee from both undermining and from higher velocities at, and in the near vicinity of, the Highway 41 bridge. Erosion protection for the rest of this reach will be provided by top soil and seeding. Low areas along the land side of the levee from station 36+00 to the upstream end of the project will be filled. Fill elevations in the low areas will be 710 from station 36+00 to 39+50, 708 from station 39+50 to 48+00, 709 from station 48+00 to 59+00, and 710 from station 59+00 to the upstream end of the project. All existing sewer lines crossing the levee will be removed and the excavations backfilled with impervious

material. Pipes that run parallel to the alignment and that are buried in the levee and/or berm prism will be either removed or grouted full length, depending on their location and depth. Interior drainage will flow from the surface through inlets to the interceptor. The inlets are surrounded with pervious material to prevent problems with uplift. The outlets for the interceptor under gravity flow conditions are located at stations 48+00 and 55+90. An existing ditch on the riverside of the levee at station 41+50 will be filled with impervious material to an elevation of 705. Where fill is required on the river side of the levee impervious material will be used above elevation 705 and either random or pervious material will be used below 705. Pervious fill will be required when fill is placed under water.

19. From station 59+50 to 71+20 a typical levee section with a 75 foot wide land side berm will be constructed. From station 71+20 to 76+50 a 75 foot wide berm will be placed on the land side of the levee constructed during Stage 2 of this project. The 75 foot wide berm will intersect the levee at elevation 713.5. The berm will be constructed with semipervious material. Erosion protection will be provided by topsoil and seeding. Where the existing levee is moved riverward (from station 59+50 to 70+00) the existing levee will be removed down to the elevation 710. The existing levee material will be used in the new levee construction. One relief well is provided at the beginning of the reach. Surface drainage and flow from the relief well are handled in the same way as in Reach 4. An access road crosses the levee at station 62+30. Existing utility lines in the levee will be removed and relocated outside the levee and berm prisms. Ditches on the riverside of the levee at stations 67+20 and 73+00 will be filled with impervious material to an elevation of 705. An inspection trench will run on the landside toe of the levee from station 59+50 to station 60+00. The inspection trench moves from the landside toe of the levee to the riverside toe of the levee between stations 60+00 and 64+00. The inspection trench will run along the riverside toe of the levee from station 64+00 to tie in to the inspection trench installed during stage 2 construction. Low areas along the land side of the levee will be filled to a minimum elevation of 710.

#### SLOPE STABILITY

20. The side slopes on the existing levees are, in general, too steep to meet current stability criteria. To improve both stability and maintainability levee slopes will be 1V to 3H.

21. Criteria used for the slope stability analysis are from EM 1110-2-1913 and EM 1110-2-1902. Computations were made using the computer programs UTEXAS2 and I0013. UTEXAS2 was used to analyze the end of construction and steady seepage cases while I0013 was used to analyze the intermediate river stage case. Stability analyses were performed for a typical levee section east of Courthouse Lake, at the East Creek levee opening (parallel to the levee alignment), at station 15+50 where the new levee is adjacent to the existing embankment around Courthouse Lake, and at station 53+60. The sudden drawdown case was not analyzed since the Minnesota River characteristically drops from flood stage very slowly.

22. The soil strengths used in the stability analyses at station 15+50, for

the typical section east of Courthouse Lake, and at the East Creek levee opening are given below:

Soil Type	Soil Description	Q		R		S	
		phi	c(psf)	phi	c(psf)	phi	c(psf)
1	soft foundation soils	0	300	14	100	24	0
2	firm foundation soils and existing embankment	0	1200	18	600	27	0
3	impervious levee fill	0	1200	18	600	27	0
5	consolidated soft foundation soils	0	550				
6	consolidated soft foundation soils	0	720				

The soil strength parameters for the impervious levee fill, the firm foundation soils, and the existing embankment were assumed to be equal to the strength of CL soils in the area that have SPT results of 4 to 14 blows per foot. The firm foundation soils are actually much stronger than this. Strengths for soil types 5 and 6 (the soft foundation soils consolidated under the first-stage loading) were determined at normal stresses of 1800 psf and 2500 psf respectively. Samples of impervious levee fill from the proposed borrow area have not been tested at this time but will be tested to verify the strength values prior to completion of the plans and specifications. Plates C-29 to C-31 show the data from the soft foundation soils strength tests. A review of the strengths showed higher values (see Plates C-32 and C-33) could have been used. Calculations will be redone using the higher strengths for the soft foundation soils once soils strengths for the borrow material are obtained.

23. The soil strengths used in the analysis at station 53+50 are as follows:

Soil Type	Soil Description	Q		R		S	
		phi	c(psf)	phi	c(psf)	phi	c(psf)
1	upper sand foundation	33	0	33	0	33	0
2	top blanket(SM)	30	0	30	0	30	0
3	exist. levee	0	1200	18	600	27	0
4	pervious fill	30	0	30	0	30	0
5	impervious fill	0	1200	18	600	27	0
6	lower sand foundation	33	0	33	0	33	0
7	riprap	36	0	36	0	36	0

SPT results from the borings were used to judge soil parameters for the upper and lower foundation sand. Parameters for the riprap were assumed. In addition the end of construction cases were generally run using non-linear shear strength envelopes for both the impervious fill and the existing levee. This results in lower strengths being used than those shown above and results in lower factors of safety than would be obtained if the shear strengths shown on plates C-25 thru C-28 were used for the existing levee.

24. The results of the slope stability analyses are given below. The sections analyzed and the critical surfaces obtained are shown on plates C-34

through C-44.

Stability Case	Factor of Safety	
	Required*	Computed
I. End of first stage of construction		
Parallel to levee at East Creek opening		1.02
Typical section east of Courthouse Lake		1.01
II. End of Construction		
Parallel to levee at East Creek opening		1.50
Typical section east of Courthouse Lake	1.3	1.36
Station 15+50	1.3	1.51
Station 53+60	1.3	1.64
III. End of Construction (landside w/ high water)		
Typical section east of Courthouse Lake	1.3	1.46
IV. Sudden Drawdown	1.0	NA
V. Intermediate River Stage		
Typical section east of Courthouse Lake	1.4	1.46
Station 53+60	1.4	1.42
VI. Steady Seepage from Full Flood Stage		
Typical section east of Courthouse Lake	1.4	1.41
Station 53+60	1.4	1.47

\*As stated in EM 1110-2-1913

25. Several alternative methods of constructing the levee from station 7+50 to 31+00 were considered and are described below.

- a. Single-stage construction with excavation and replacement of the soft foundation soils. This would require excavation to elevation 685 under the levee prism and stability berms about 9 feet high and 100 feet wide on each side of the levee.
- b. Single-stage construction with sand piles installed through the soft foundation soils. With no stability berm, this would require 2-foot diameter sand piles spaced 3 feet center to center.
- c. Two-stage construction with sand drains installed through the foundation soils. This would require 2-foot diameter sand drains spaced at 10 feet center to center and stability berms about 6 feet high and 30 feet wide.
- d. Two-stage construction with "wick" drains installed through the soft foundation soils. This method requires 30-foot wide stability berms and "wick" drains spaced at 5 feet center to center.

The two-stage "wick" drain method of construction was considered the best



alternative.

#### SETTLEMENT

26. The CSETT (I0019) computer program along with several 20/20 spreadsheet computations were used to determine the settlement between stations 7+50 and 31+00. CSETT was used to evaluate the time rate of settlement without "wick" drains under the embankment. Methodology from "Designing With Geotextiles" by Robert M. Koerner was used to determine the time rate of settlement when using the "wick" drains. CSETT was used to determine settlement after the first stage of construction and total settlement. A total settlement of 3.5 feet will occur at the centerline of the levee. The majority of this settlement (2.7 feet) will result from the first stage loading. A 1' overbuild will be required on this portion of the levee. The following table shows settlement of the levee from station 7+50 to 21+50. Settlement of the riverward portion of the levee from station 21+50 to 31+00 will be similar.

Distance from centerline(feet)	0	20	40	60	80	100	120
Stage 1 settlement(feet)	2.73	2.73	2.72	2.68	2.24	1.21	0.11
Total settlement(feet)	3.56	3.26	*	*	*	*	*
Difference	0.83	0.53					

\*Note: At distances of 40 feet or more from the centerline, excavation of the berms for Stage 2 construction results in an unloading of the soft foundation soils. Consequently, the total settlement at these locations will be what occurs under the Stage 1 loading.

27. The centerline of the levee from the sewage treatment plant upstream to about station 42+00 has been moved considerably riverward of the centerline of the existing levee. The riverward shift of the levee in combination with the higher levee and the 1V to 3H riverward slope results in a significant portion of the new levee being placed on potentially soft foundation soils riverward of the existing levee. "Wick" drains and a berm are presently shown along the riverside of the levee in this area. During the plans and specifications phase the levee will either be moved landward to minimize fill placement on the riverward side of the existing levee or borings will be taken riverward of the existing levee to confirm the need for the berms and "wick" drains.

28. Because of the riverward shift in the levee alignment between stations 60+00 and 70+00, borings, testing, and settlement analyses will be required along the new levee alignment to determine the amount of overbuild required. The new borings will also allow verification of foundation conditions for seepage, uplift, and slope stability.

## SEEPAGE AND UPLIFT

29. Due to the nature of the foundation materials there will be minimal seepage from station 0+00 to 34+50.

30. The borings taken along the levee alignment upstream of station 34+50 show foundation conditions typical of those that cause seepage and uplift problems during a flood. These foundation conditions include deep layers of relatively clean sands and (upstream of about station 60+00) a layered foundation of relatively clean sands, silts, and clays. High rates of seepage, small sand boils, and "quick" or "near-quick" conditions have been reported landward of the levee during past floods. Records indicate that approximately 20,000 gpm were pumped during the peak of the 1969 flood, which crested at 720.3. However, this figure includes sanitary wastewater, groundwater infiltration to the sanitary system, and other interior runoff. Based on precipitation records at Minneapolis, Minnesota, the limited reevaluation report roughly estimated between 5000 and 10000 gpm of underseepage.

31. Criteria used in the analysis are from EM 1110-2-1913 which require a minimum factor of safety of 1.5 against uplift and a maximum allowable upward gradient of 0.5 at the levee toe. Computer programs used in the analyses were LEVEEMSU and 20/20 spreadsheets. Permeabilities for the pervious layer under the levee are based on  $D_{10}$  sizes and Figure 3-5 in EM 1110-2-1913. Although three other methods (a method from "Construction Dewatering" by J. Patrick Powers, Hazen's equation, and the Mash and Denny relationship from EM 1110-2-1901) were used to determine the horizontal permeabilities of the pervious layers for comparison purposes, the method from EM 1110-2-1913 was generally used for design. In general all these methods except the one from "Construction Dewatering" were developed for SP or SW type soils and the majority of the soils in the pervious layers are SP-SM soils. The permeability of the riverside blanket materials were obtained from Table C-1 in EM 1110-2-1913 and the permeabilities of the landside top stratum were obtained from Table 38 in TM 3-424. Relief wells were designed using computer program I0015. Relief wells were designed to provide a factor of safety against uplift of 1.7 at the midpoint location between relief wells. The percent penetration of the well screen in the transformed foundation was determined in accordance with the method shown on page 293 of TM 3-424 (same as using equations 9-24 to 9-29 in EM 1110-2-1901). EM 1110-2-1901 recommends oversizing the well screen and gravel pack area to allow for clogging. The current design is based on a 33% decrease in the well screen and gravel pack area before well maintenance is required.

32. Seepage and uplift calculations were generally made at each boring along the levee alignment. The seepage quantities were calculated using a water surface elevation 3 feet below the top of the levee. Uplift pressures were calculated using the water surface at the top of the levee. A summary of seepage quantities is shown in Table 1. A summary of seepage and uplift calculations is shown in Table 2. The exit gradients were greater than 0.5 from station 78+00 to 84+00 when using permeabilities from the  $D_{10}$  size and figure 3-5 of EM 1110-2-1913. Using permeabilities from Hazen's equation the exit gradient from station 78+00 to 81+00 was below 0.5 but the exit gradient from 81+00 to 84+00 was still greater than 0.5. An exit gradient (11 in Table

2) was determined for the top stratum of the top blanket and this gradient was below 0.5.

33. In general the land surface rises with increasing distances from the river. The analysis method contained in the EM assumed a flat grade either side of the levee. LEVEEMSU was used to check the adequacy of the design where there was both a landside and riverside top blanket. It was assumed that the aquifer is generally unconfined when the ground surface rises beyond the landside levee toe and that the phreatic surface landward of the levee toe is generally equal to the minimum landside ground surface. The LEVEEMSU results were consistent with those obtained using the EM 1110-2-1913 methodology. A slightly higher gradient was obtained between station 34+50 and 36+30 because LEVEEMSU was able to model a partial seepage block.

34. Since the calculations were completed, the levee centerline between Pine Street and Hickory Street has been moved riverward. An additional well was added north of Pine Street to reduce the berm width in that area. Although it is not anticipated that these changes will materially affect the seepage quantities or uplift pressures, the calculations have not been revised due to time constraints. The calculations will be checked during the plans and specifications phase.

35. There is a good possibility that the depths of the wells may be reduced during construction if shallower continuous impervious layers are found in the pervious aquifer when the pilot borings are made for each well. One area where this may occur is along the levee between Maple and Ash Streets. If the intermediate cutoff layer is found to be continuous between three to four-hundred feet of well screen could be saved.

#### SOURCE OF CONSTRUCTION MATERIALS

36. Impervious fill will be obtained from an existing borrow area just west of Chaska on County Highway 10. The city has an agreement with the borrow area owner to purchase material from this site. Sampling and testing of the material will be performed during preparation of the plans and specifications for the project.

37. Granular fill of adequate quality is available within 10 miles of Chaska. Pervious fill is defined as material with 100% passing the number 4 sieve and less than 5% passing the number 200 sieve. Semi-pervious fill is defined as 100% passing the number 4 sieve and from 5% to 12% passing the number 200 sieve. Either semi-pervious or pervious material shall be used to construct the landside berms upstream of station 34+50.

38. Riprap and bedding of adequate quality can be obtained from existing quarries located within 40 miles of Chaska. The construction contractor for the Stage 2 work obtained riprap from a quarry in New Ulm, Mn., which is 65 miles from Chaska.

39. Concrete aggregate of adequate quality can be obtained from continuously operating natural aggregate and crushed rock sources in the Minneapolis-St.

Paul, Minnesota, metropolitan area. The distance from the project to reliable sources in this area would be 25 to 50 miles. Closer sources located within 10 miles of Chaska exist but produce concrete aggregate on an intermittent basis. Although only one of these sources has been tested for Corps of Engineers projects, information obtained from the Minnesota Department of Transportation indicates most of these sources would be adequate for concrete aggregate.

#### CONSTRUCTIBILITY

40. Between stations 7+50 and 31+00 instrumentation will be required to monitor both stages of levee construction over the soft foundation soils. The design, location, and monitoring plan for the instrumentation will be developed during the plans and specifications phase. It is anticipated that instrumentation for the soft foundation soils will include piezometers, settlement plates, and slope indicators at selected locations. The specifications need to contain language that allows Government control of fill placement rates and of the period of time between the completion of fill placement for Stage 1 and the commencement of fill placement for Stage 2. The two foot thick pervious fill construction pad and the "wick" drains should be installed in the levee opening for East Creek to avoid a future mobilization for these operations.

41. Any excess impervious fill removed from the levee section(berm) between stations 7+50 and 34+00 shall be stockpiled for future use. The excess material could be used to fill the opening in the levee at East Creek or possibly for Stage 3 construction.

42. The city of Chaska has requested removal of the existing levee between the County Courthouse and Courthouse Lake. If classification tests confirm that the existing levee material is impervious the material could be used in the new levee construction. Removal of the existing levee would have to be timed so that the existing flood protection at Chaska is not significantly reduced.

43. Each relief well will require a pilot boring. Samples must be taken at appropriate depth intervals(5 feet or at every change in soil type) so soil permeabilities can be checked(using the  $D_{10}$  methodology) to insure design conditions are applicable and to insure proper installation of the wells. The depth of the pertinent aquifer also needs to be verified. The final well spacing may vary from design spacing. Pump tests of selected wells will be required to check design permeability.

44. During installation of the interceptor piping care must be taken to insure that the integrity of the top blanket is restored.

45. Existing sewer lines crossing the levee will be removed. To insure through seepage will not be a problem the excavations will be backfilled with impervious materials even though in most cases the sewer lines are below the top blanket material. The existing sewer lines on the riverside of the levee will be filled full length with grout.

#### FURTHER INVESTIGATIONS AND/OR ANALYSES

46. The items listed below which will require further investigations/analyses to complete before the plans and specifications.

- a. The borrow area for impervious fill must be located, sampled and tested.
- b. Slope stability analyses need to be checked once strength tests are obtained for the impervious borrow material. At the same time, the revised strengths shown on Plates C-32 and C-33 will be used where appropriate.
- c. If the levee alignment between stations 31+00 and 42+00 is not moved landward, additional borings and testing will be required to verify the need for the "wick" drains and the berm on the riverward side of the levee and to evaluate settlement of the 24 inch ductile iron pipe that crosses the levee at about station 32+00.
- d. Seepage, stability, and settlement/overbuild need to be reevaluated between stations 59+50 and 70+00, where the levee alignment has been shifted about 70 feet riverward of the existing alignment. Two new borings are recommended along the riverward toe of the new levee to determine foundation conditions in this reach. Depending on the subsurface conditions shown by the new borings, additional sampling and testing of the foundation soils may also be required.
- e. Design instrumentation and monitoring plan for staged construction over the soft foundation soils from station 7+50 to station 31+00.
- f. Design the well screen and the gravel pack gradation for the relief wells.
- g. Select the bedding gradation and the filter fabric for the riprap.
- h. Determine if the existing levee on the west side of Courthouse Lake contains material suitable for use in constructing the new levee. If so, determine acceptable timing for removal of the existing levee.

\*\*\*\*\*  
TABLE NO. 1  
\*\*\*\*\*

Seepage Quantities for Chaska, Stage 4

Section Number		applied between station	Reach Length (ft)	Seepage Quantities					
				exist. unit gpm/ft	total gpm	design unit gpm/ft	total gpm	well flow unit gpm/ft	total gpm
0 + 0									
0			3450	0	0	0	0	0	0
34+ 50									
1			80	0.766	61.28	0.766	61.28		0
35+ 30									
2			370	2.043	755.91	0.195	72.15	2.55	943.5
39+ 0									
3			480	2.009	964.32	0.372	178.56	2.237	1073.76
43+ 80									
4			480	3.354	1609.92	0.305	146.4	4.609	2212.32
48+ 60									
5			320	3.33	1065.6	0.417	133.44	4.866	1557.12
51+ 80									
6 upper			430	1.667	716.81	0.2	86	2.182	938.26
6 lower									
6 lower			430	2.073	891.39	2.073	891.39		0
56+ 10									
7 upper			330	0.824	271.92	0.137	45.21	1.04	343.2
7 lower									
7 lower			330	2.846	939.18	2.846	939.18		0
59+ 40									
8-well			160	0.284	45.44	0.14	22.4	0.168	26.88
61+ 0									
8			180	0.284	51.12	0.284	51.12		0
62+ 80									
9			420	0.222	93.24	0.222	93.24		0
67+ 0									
10			850	0.346	294.1	0.342	290.7		0
75+ 50									
11**			325	0.14	45.5	0.14	45.5		0
78+ 0									
12			300	0.381	114.3	0.381	114.3		0
81+ 0									
13			300	0.627	188.1	0.627	188.1		0
84+ 0									
14			775	0.243	188.325	0.243	188.325		0
91+ 75									
				8296.46		3547.3		7095.04	
								*1.33=	9436.4
grand total===== 12983.7									

notes:

- 1.The above assumes an intermediate cutoff at elev. 664 between Walnut and Pine streets which limit pressures to those in the top portion of the aquifer.
- 2.Well flow is increased by 1.33% to comply with the EM 1110-2-1901 requirement that relief wells be designed with a factor of safety against clogging.
- 3.Finished grade landside minimum elevation @ 710 from 36+00-39+50
- 4.Finished grade landside minimum elevation @ 708 from 39+50-48+00
- 5.Finished grade landside minimum elevation @ 709 from 48+00-59+00
- 6.Finished grade landside minimum elevation @ 710 from 59+00-91+75
- 7.8" wells, riser @ 706, 59' deep, 102'o.c., 35+81-39+89
- 8.8" wells, riser @ 706, 59' deep, 72'o.c., 40+61-44+21
- 9.8" wells, riser @ 706, 60' deep, 46'o.c., 44+67-48+35
- 10.8" wells, riser @ 706, 48' deep, 67'o.c., 49+02-51+70
- 11.8" wells, riser @ 706, 39' deep, 74'o.c., 52+44-55+80
- 12.8" wells, riser @ 706, 38' deep, 80'o.c., 55+80-59+40
- 13.8" wells, riser @ 706, 10' deep, 60+30

\*\*note the change in stationing, 77+00=76+25 GDM stationing

*****							
TABLE NO. 2							
Reach	34+50 to 35+30		35+30 to 39+00		39+00 to 43+80		43+80 to 48+60
Section	1		2		3		4
top of levee	728.7		728.7		728.7		728.9
top blanket material	SP,SC,SM		SM		SM		SM
top blanket elevation	710.5		710		708		708
bottom blanket elevation	701		707.2		705		705.7
bottom aquifer	626.2		626.2		626.6		634.2
L1	200		200		200		NA
L2	119.2		122.2		134.2		135.4
L3	1000		1000		1000		1000
Zt	8.2		2.8		3		2.3
Zbl	3.9		2.8		3		2.3
Kbl	0.0008		0.002		0.002		0.002
Zbr	3.7		2.8		3		NA
Kbr	0.00016		0.0014		0.0014		NA
Df	74.8		81		78.8		71.5
Kf	0.105		0.069		0.061		0.088
head used for uplift design	18.2		18.7		20.7		20.9
head used for seepage design	15.2		15.7		17.7		17.9
X3	195.7		88.5		84.9		85.1
X1	851		110.6		97.6		.430f
shape factor "S"	0.06416		0.2521		0.24879		0.28462
uplift head at levee toe	3.1		5.1		5.5		7.1
resisting wgt. at levee toe	515.8		175.3		187.8		144
F.S. at levee toe against uplift	2.71		0.55		0.54		0.33
Qs	0.766		2.043		2.009		3.354
Io	0.37		1.84		1.85		3.08
I1							

Berm info						
Xsp		112.9		109.8		198.2
thickness at levee toe		3.5		3.8		6.2
Xp		72.8		70.4		114.9
thickness at levee toe		2.1		2.3		3.6
qp, flow per foot of levee(gpm)		1.36		1.32		2.9
Xs		99.5		96.7		170.5
thickness at levee toe		2.7		2.9		4.6
XI		417.5		415.6		715.4
thickness at levee toe		7.2		8		10.4
well info						
top of riser elevation		706		706		706
l.s.water		710		708		708
spacing		102		72		46
% penetration		80		80		80
hw		-3.795		-1.895		-1.839
havl		4.651		3.12		2.718
TM		0.792		0.724		0.632
TAV		0.676		0.616		0.537
h,mid1		1.6541		1.77201		1.35984
Qew		2.55		2.237		4.609
Qsw		0.195		0.372		0.305
Qtotal		2.745		2.609		4.914
Boring	79-12M	89-122M		89-125M		89-123M
section	1	2		3		4
notes:						

Notes:

1. Terms shown above are from EM 1110-2-1913(Appendices B and C) or WES program I0015(Design For Infinite Series Of Relief Wells).
2. "I1" is the exit gradient of the top stratum of the top blanket.
3. "h,mid1" is the head at the landside toe of the levee at the midpoint distance between relief wells.
4. For typical seepage calculation see PLATES C-48 through C-54.



*****							
TABLE NO. 2 (continued)							
Reach	48+60 to 51+80	51+80 to 56+10		56+10 to 59+40			
Section	5	6	6		7	7	
top of levee	728.9	729.2	729.2		729.2	729.2	
top blanket material	SM	SM	SM		SM,CL	SM,CL	
top blanket elevation	709.5	709.5	709.5		709	709	
bottom blanket elevation	706.2	706	663.3		705	664	
bottom aquifer	613	664.6	564.7		665.2	576	
L1	NA	NA	NA		25	25	
L2	126.4	128.2	128.2		131.2	131.2	
L3	1000	1000	1000		1000	1000	
Zt	3.3	3.5	46.2		4	45	
Zbl	3.3	3.5	4.4		3.4	9.5	
Kbl	0.002	0.002	0.001		0.0008	0.0008	
Zbr	NA	NA	NA		3.1	7.8	
Kbr	NA	NA	NA		0.00016	0.00016	
Df	93.2	41.4	98.6		39.8	88	
Kf	0.081	0.07	0.057		0.038	0.133	
head used for uplift design	19.4	19.7	19.7		20.2	20.2	
head used for seepage design	16.4	16.7	16.7		17.2	17.2	
X3	111.607	71.2	169.3		80.2	372.8	
X1	.43Df	.43Df	.43Df		24.8	25	
shape factor "S"	0.33515	0.19059	0.29111		0.1685	0.16635	
uplift head at levee toe	7.8	6.5	9.8		6.9	14.2	
resisting wgt. at levee toe	206.6	219.1	2883.5		250.4	2817	
F.S. at levee toe against uplift	0.43	0.54	4.69		0.59	3.17	
Qs	3.33	1.667	2.073		0.824	2.846	
Io	2.36	1.85	0.21		1.71	0.32	
I1							

Berm info						
Xsp	184.6		88.4			88.2
thickness at levee toe	5.7		4.3			4.3
Xp	120.9		60			61.6
thickness at levee toe	3.6		2.7			2.8
Qp,flow per foot of levee(gpm)	2.61		1.12			0.52
Xs	163.4		79			79.3
thickness at levee toe	4.4		3.3			3.3
XI	542		283.7			270.1
thickness at levee toe	8.8		7.7			7.5
well info						
top of riser elevation	706		706			706
l.s.water	709.5		709.5			709
spacing	67		74			80
% penetration	70		90			98
hw	-3.203		-3.364			-2.94
hav1	4.554		4.477			4.37
TM	0.794		0.658			0.622
TAV	0.702		0.543			0.512
h,mid1	1.94782		2.06117			2.36887
Qew	4.866		2.182			1.04
Qsw	0.417		0.2			0.137
Qtotal	5.283		2.382			1.17
Boring	89-124M		89-118M			73-1M
section	5		6	6		7 7
notes:						

Notes:

1. Terms shown above are from EM 1110-2-1913(Appendices B and C) or WES program 10015(Design For Infinite Series Of Relief Wells).
2. "I1" is the exit gradient of the top stratum of the top blanket.
3. "h,mid1" is the head at the landside toe of the levee at the midpoint distance between relief wells.
4. The first column in section 6 is the analysis of the upper aquifer at that section. The second second column in section 6 is the analysis for the deeper aquifer at that section.
5. The first column in section 7 is the analysis of the upper aquifer at that section. The second second column in section 7 is the analysis for the deeper aquifer at that section.
6. For typical seepage calculation see PLATES C-48 through C-54.

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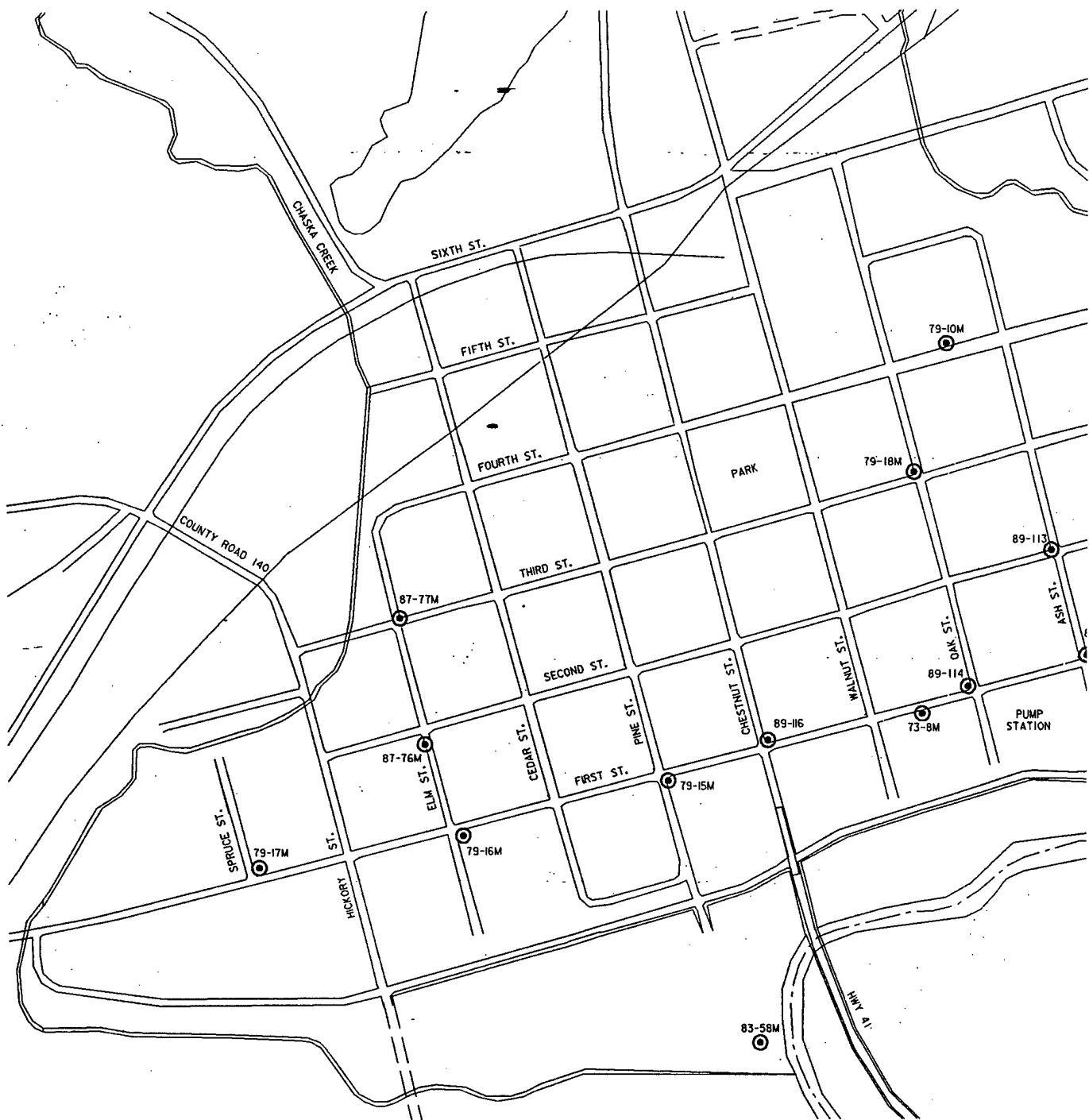
TABLE NO. 2 (continued)								
Reach	59+40 to 62+80			62+80 to 67+00			67+00 to 75+50	
Section	8	8		9	9		10	10
top of levee	729.2	729.2		729.2	729.2		729.2	729.2
top blanket material	CL	SM,CL		GC,SM	SM,GC,SM		SM,SC,CL	SM,SC,CL
top blanket elevation	710	713		710	713		710	713
bottom blanket elevation	705	705		704	704		705	705
bottom aquifer	693.7	693.7		688	688		688	688
L1	300	300		250	250		250	250
L2	125.2	107.2		125.2	107.2		125.2	107.2
L3	1000	1000		1000	1000		1000	1000
Zt	5.5	8		6	8		5	8
Zbl	5.5	6.3		5	6.5		4.1	5.3
Kbl	0.0006	0.0006		0.001	0.001		0.0008	0.0008
Zbr	5.5	5.7		4.6	5.4		3.7	4
Kbr	0.0001	0.0001		0.0004	0.0004		0.00016	0.00016
Df	11.3	11.3		16	16		17	17
Kf	0.087	0.087		0.028	0.028		0.056	0.056
head used for uplift design	19.2	16.2		19.2	16.2		19.2	16.2
head used for seepage design	16.2	13.2		16.2	13.2		16.2	13.2
X3	94.9	101.6		47.3	54		69.8	79.4
X1	199.8	201.9		71.6	77.5		138.5	142.7
shape factor "S"	0.02691	0.02751		0.06553	0.06704		0.05097	0.05163
uplift head at levee toe	4.3	4		3.7	3.7		4	3.9
resisting wgt. at levee toe	343.8	500		332.5	505		305	477.5
F.S. at levee toe against uplift	1.27	2		1.43	2.21		1.22	1.96
qs	0.284	0.236		0.222	0.185		0.346	0.285
Io	0.79	0.5		0.74	0.46		0.8	0.49
I1								

Berm info									
Xsp									
thickness at levee toe									
Xp									
thickness at levee toe									
qp, flow per foot of levee(gpm)									
Xs									
thickness at levee toe									
XI									
thickness at levee toe									
well info									
top of riser elevation	706								
l.s.water	710								
spacing	320								
% penetration	96								
hw	-3.88								
hav1	6.185								
TM	0.871								
TAV	0.766								
h,mid1	3.15281								
Quew	0.168								
Qsw	0.14								
Qtotal	0.308								
Boring	89-121M			79-19M			80-23M		
section	8	8		9	9		10	10	
notes:									

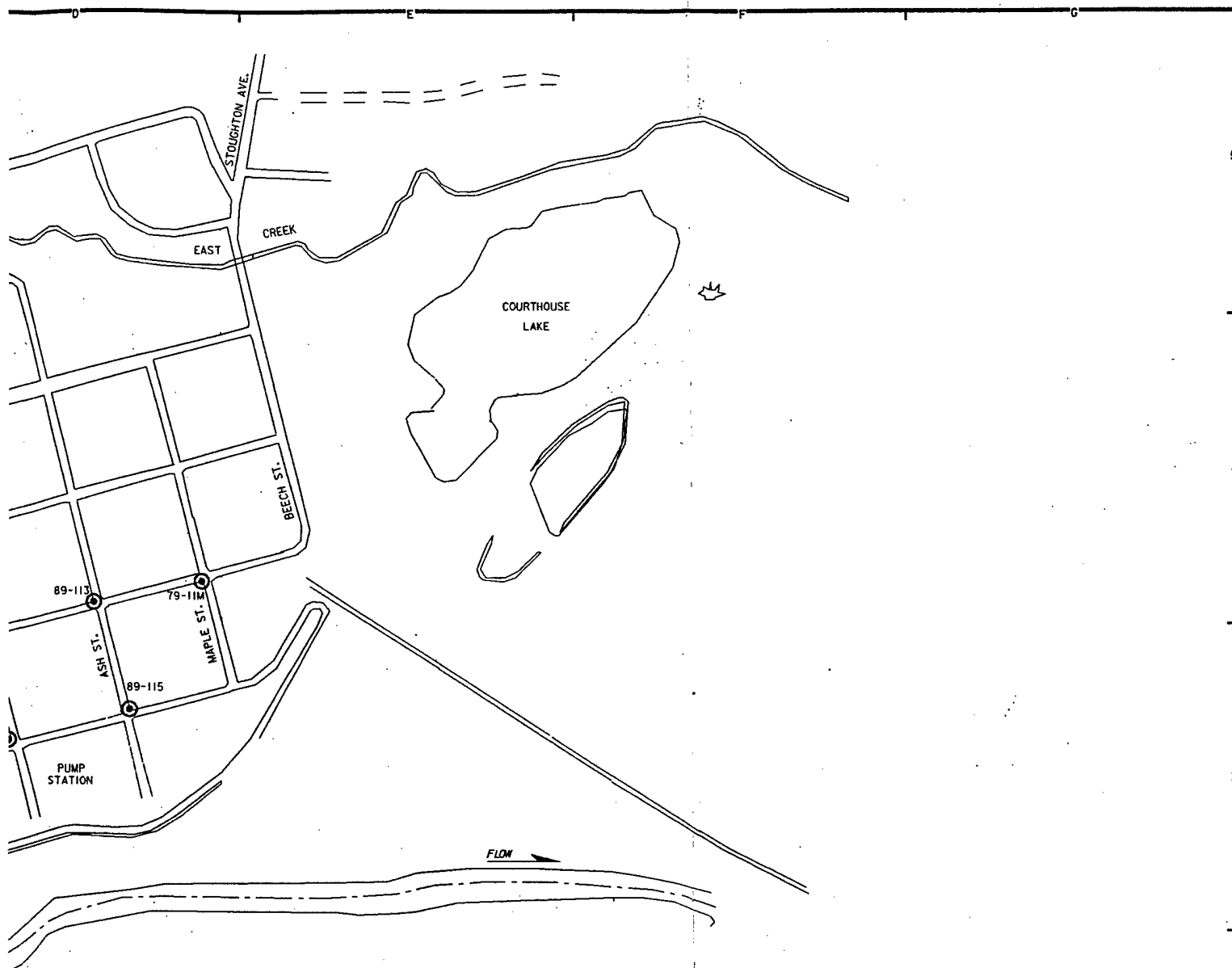
Notes:

1. Terms shown above are from EM 1110-2-1913(Appendices B and C) or WES program 10015(Design For Infinite Series Of Relief Wells).
2. "I1" is the exit gradient of the top stratum of the top blanket.
3. "h,mid1" is the head at the landside toe of the levee at the midpoint distance between relief wells.
4. The first column in section 8 is the analysis used for the design of the relief well at that section. The second column is the analysis at that section with a berm with a top elevation of 713.
5. The first column in section 9 is the analysis of the existing condition with the landside ground elevation of 710. The second column is the analysis at that section with a berm with a top elevation of 713.
6. The first column in section 10 is the analysis of the existing condition with the landside ground elevation of 710. The second column is the analysis at that section with a berm with a top elevation of 713.
7. For typical seepage calculation see PLATES C-48 through C-54.

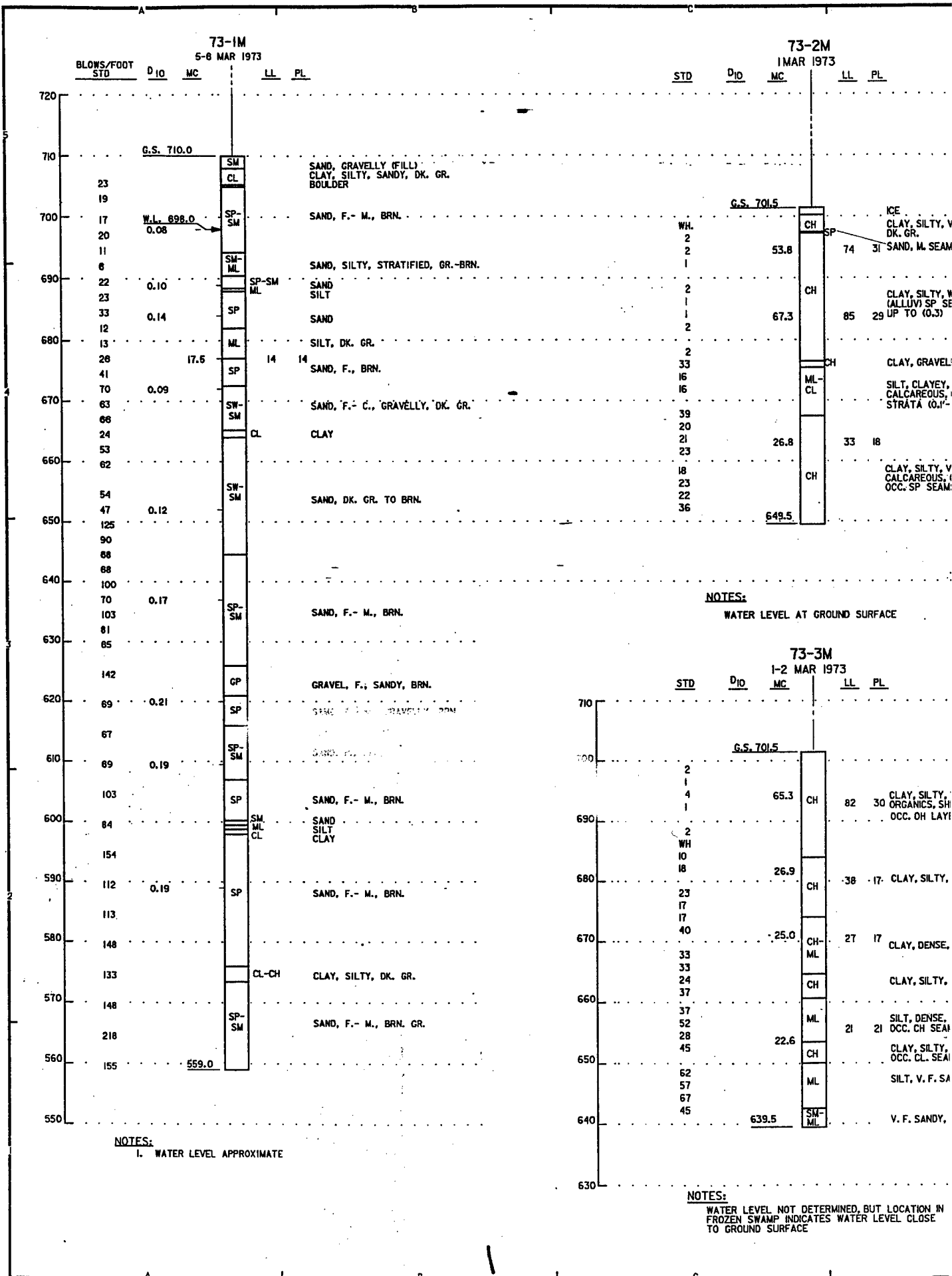
*****									
TABLE NO. 2 (continued)									
Reach	75+50 to 78+00		78+00 to 81+00		81+00 to 84+00		84+00 to 91+75		
Section	11		12	12		13	13		14
top of levee	729.2		729.2	729.2		729.2	729.2		729.2
top blanket material	CL,OL,CH SC,SP-SM		SC,SM,SC	SC,SM,SC		SM,ML,SP-SM	SM,ML,SP-SM		SM-ML,CL
top blanket elevation	710		715	715		719	719		720
bottom blanket elevation	696		705.3	705.3		709	709		707.5
bottom aquifer	686		685.3	685.3		693	693		675
L1	100		80	80		90	90		60
L2	125.2		95.2	95.2		71.2	71.2		65.2
L3	1000		1000	1000		1000	1000		1000
Zt	14		9.7	9.7		6.5	6.5		12.5
Zbl	10.7		7.8	7.8		4	4		8.3
Kbl	0.0006		0.0008	0.0008		0.001	0.001		0.0008
Zbr	10.5		7	7		2.7	2.7		6.7
Kbr	0.0001		0.00016	0.00016		0.0014	0.0014		0.00016
Df	10		15.4	15.4		16	16		27
Kf	0.034		0.084	0.036		0.19	0.077		0.046
head used for uplift design	19.2		14.2	14.2		10.2	10.2		9.2
head used for seepage design	16.2		11.2	11.2		7.2	7.2		6.2
X3	77.9		112.3	73.5		110.3	70.2		113.5
X1	91.6		77.1	73.6		79.8	68.9		58.7
shape factor "S"	0.03394		0.05411	0.06354		0.06125	0.07607		0.11375
uplift head at levee toe	5.1		5.6	4.3		4.3	3.4		4.4
resisting wgt. at levee toe	882.5		590.8	590.8		409.2	409.2		704.8
F.S. at levee toe against uplift	2.79		1.69	2.2		1.52	1.93		2.57
qs	0.14		0.381	0.192		0.627	0.315		0.243
Io	0.36		0.58	0.44		0.66	0.52		0.35
I1						0.57	0.45		
Qtotal									
Boring	79-21M		83-55M			89-105M			82-37M
section	11		12	12		13	13		14
notes:	station change		Hazen's			Hazen's			



**PLAN**  
**BORING LOCATIONS**  
SCALE: 1" = 250'-0"



SYMBOL	DESCRIPTION	DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER <b>CHASKA CREEK STAGE 4</b> CHASKA, MINNESOTA</p>	
<p>DESIGNED: _____</p>		<p><b>BORING LOGS</b></p>	
<p>CHECKED: _____</p>		<p><b>BORING LOCATIONS</b></p>	
<p>DRAWN: LKT</p>		<p><b>FOR BORINGS NOT SHOWN ELSEWHERE</b></p>	
<p>DESIGNED: JRC</p>		<p>CAD FILE NAME: NC05RMAP.DGN</p>	
<p>CHECKED: JRC</p>		<p>DRAWING NUMBER:</p>	
<p>DATE: 05-04-91</p>		<p>SPEC NO: DACW37-90-B-0000</p>	
<p align="center"><b>PLATE C-1</b></p>		<p align="right">SHT 1 OF 14</p>	





## 84-IM

DATE OF BORING

GROUND SURFACE ELEVATION AT BORING

WELL GRADED GRAVELS, GRAVEL - SAND MIXTURE, LITTLE OR NO FINES

POORLY GRADED GRAVELS, LITTLE OR NO FINES

SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES

CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES

WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES

POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES

**SILTY SANDS, SAND - SILT MIXTURES**

CLAYEY SANDS, SAND - CLAY MIXTURES

INORGANIC SILTS. LIQUID LIMIT LESS THAN 50

INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50

INORGANIC CLAYS, LOW TO MEDIUM PLASTICITY, LIQUID LIMIT LESS THAN 50

INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50

ORGANIC SILTS OR CLAYS, LOW PLASTICITY, LIQUID LIMIT LESS THAN 50

ORGANIC SILTS OR CLAYS, MEDIUM TO HIGH PLASTICITY, LIQUID LIMIT

**GREAT  
PEAT**

BORDERLINE MATERIAL

STRATIFIED MATERIAL

LOCATION AND SAMPLE NUMBER FOR UNDISTURBED SAMPLE

**NO RECOVERY**

WATER LEVEL ON DATE OF BORING

ELEVATION AT BOTTOM OF BORING

## I. GENERAL :

THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. THE LEGEND REPRESENTS ONLY THE BASIC SOILS TO COMPLETE THE CLASSIFICATION. PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING STAFF. NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

**2. MOISTURE CONTENT:**

THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (MC) IS SHOWN TO THE LEFT OF THE BORING LOG.

**3. BLOW COUNT (SPT):**

BLow COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTED, ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12" STANDARD BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST (SPT) USING: 1-3/8" X 2" SAMPLER, 140 LB HAMMER AND A 30" DROP. FOR NON-STANDARD BLOW COUNTS, SAMPLER SIZE, HAMMER WEIGHT AND HEIGHT OF DROP ARE AS SHOWN.

4. ATTERBERG LIMITS:

LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO RIGHT OF THE BORING  
STAFF.

5.  $D_{10}$  SIZE:

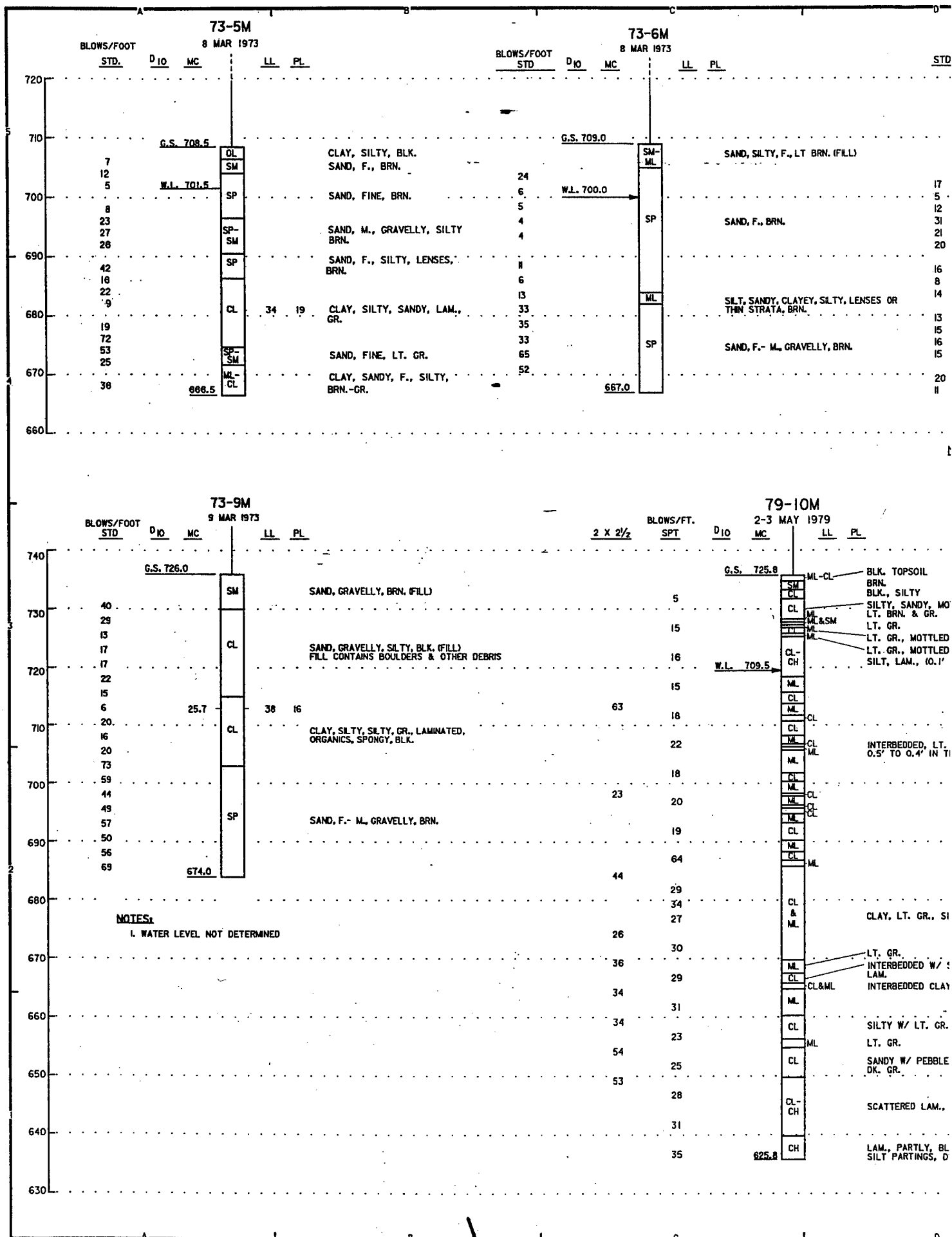
THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO THE LEFT OF THE BORING STAFF.

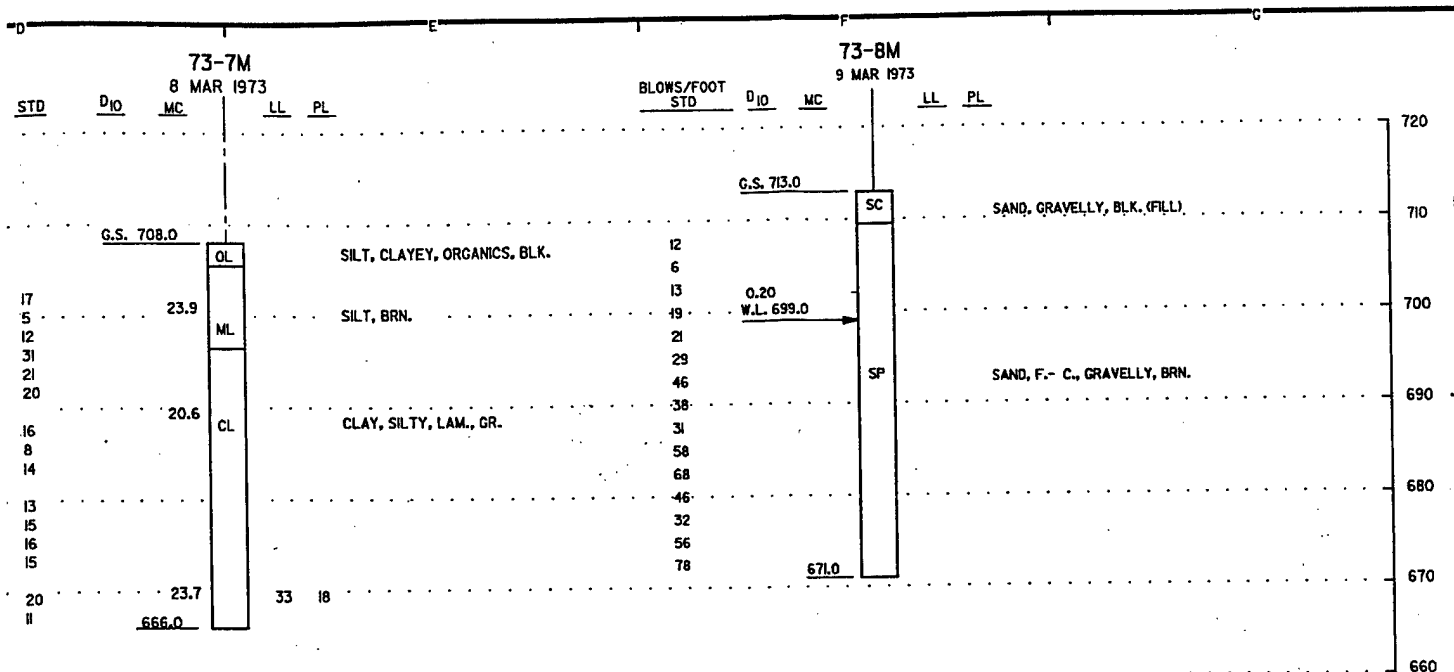
Interval	Remarks
720	
710	
700	1, V. SOFT, ORGANIC, SHELLS.
690	2AM (0.2)
680	
670	1, WET, SHELLS, DK. GR. SEAMS (0.1') ORGANIC SEAMS 2)
660	
650	1ELLY, SANDY, BRN-GR.
640	2Y. MED. DENSE, MOIST-WET, 1S, GR-BRN 1P- 0.4') M
630	
620	1, V. STIFF, MOIST, LAM., 1S, GR. 1AMS (0.1'-0.3')
610	
600	

DEPTH (FEET)	SOIL DESCRIPTION
710	
700	
690	TY. WET, SHELLS, SL. SHELLS, DK. GR. LAYERS (0.2')
680	TY. STIFF, MOIST, MED. GR.
670	SE, V. STIFF, MOIST, DK. GR.
660	TY, V. STIFF, MOIST, DK. GR.
650	SE, SAT., GR SEAMS (0.2') TY, V. STIFF, MOIST, DK. GR. SEAMS (0.1') SANDY, V. DENSE, SAT., GR.
640	DY, SILTY, DENSE, SAT., GR.
630	

**IN**  
**E**

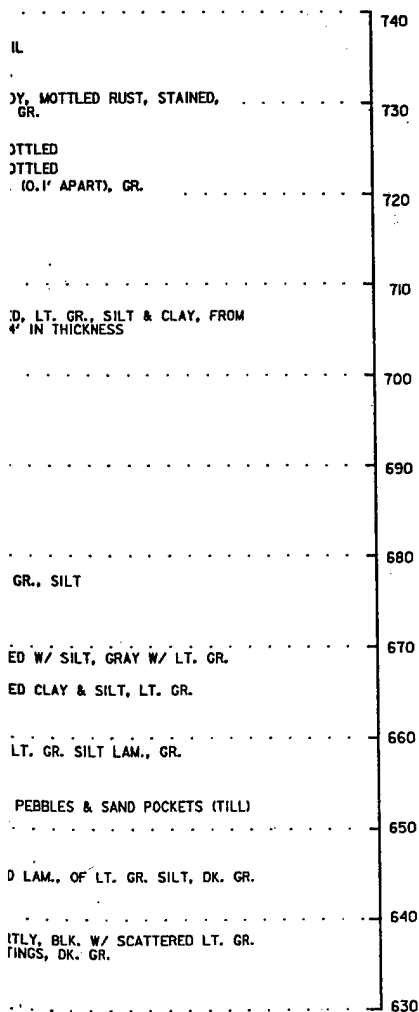
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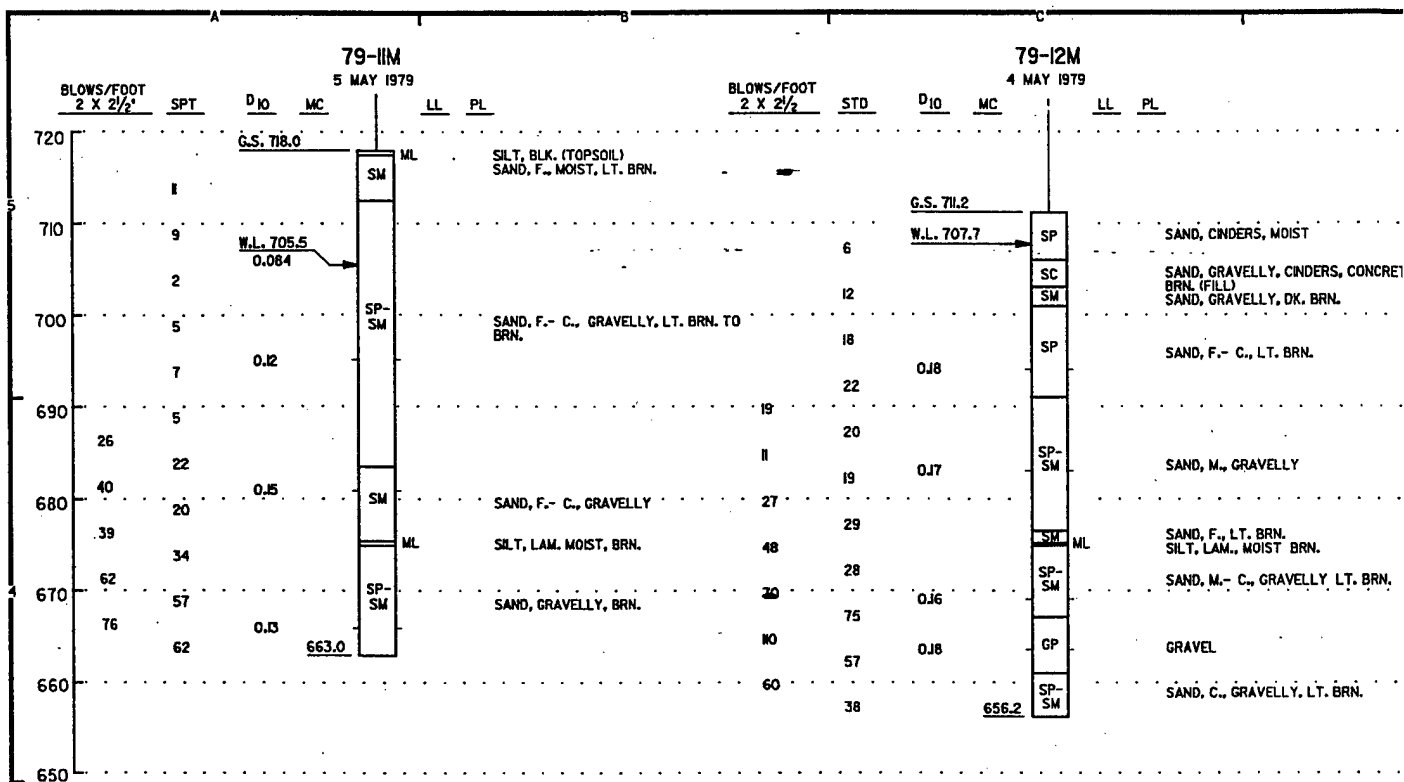
**NOTES:**

WATER LEVEL NOT DETERMINED



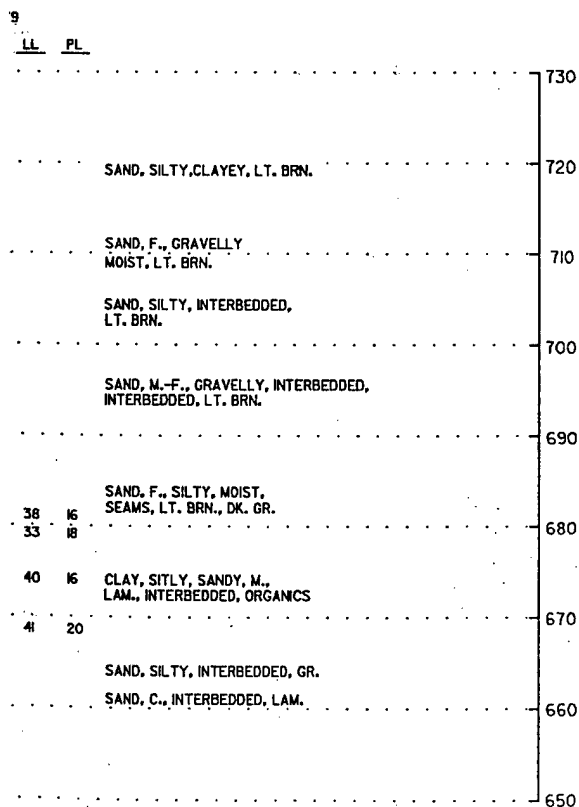
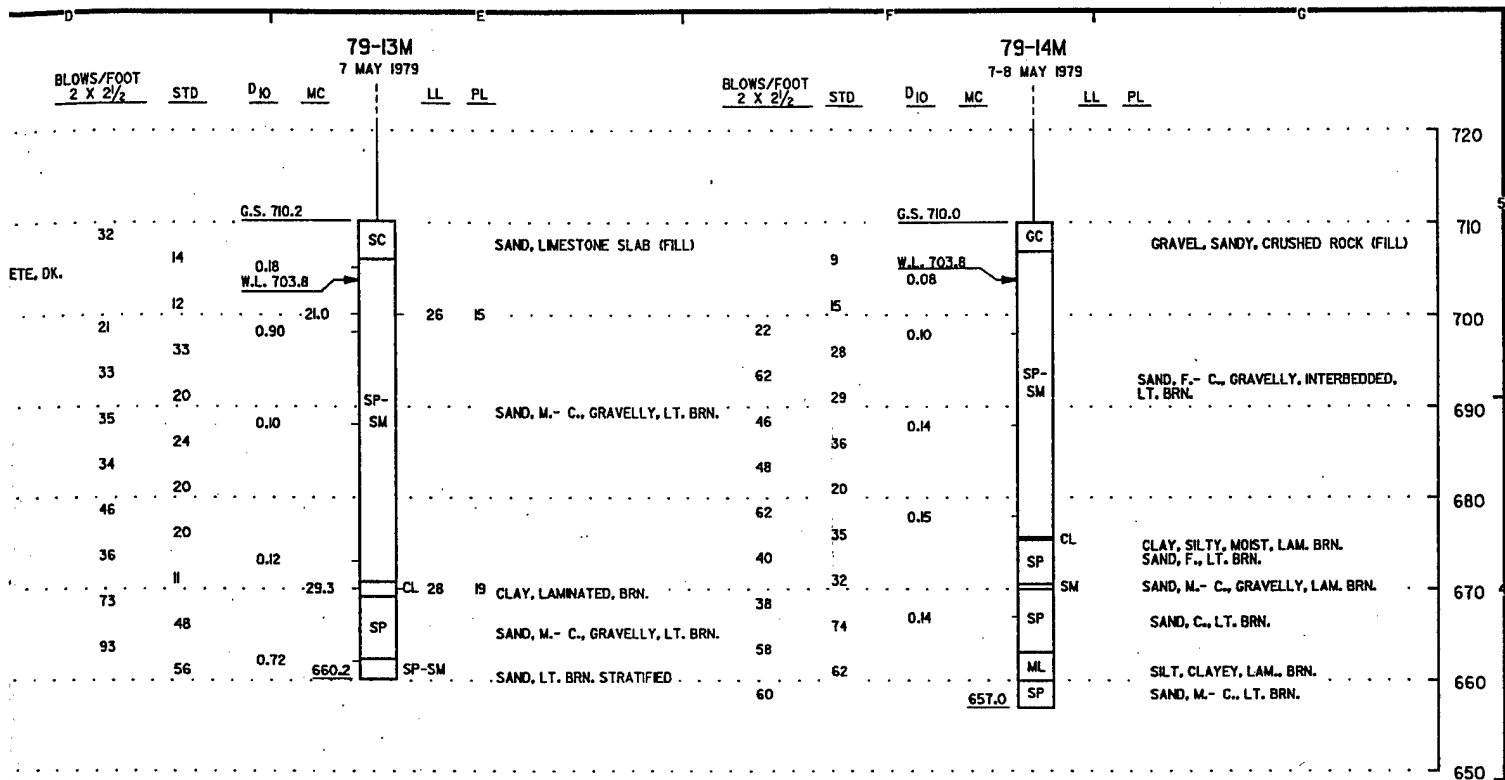
SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		DESIGN MEMORANDUM NO. 2			
		CHASKA STAGE 4			
		FLOOD CONTROL - MINNESOTA RIVER			
DESIGNED:		CHASKA CREEK STAGE 4		CHASKA, MINNESOTA	
CHECKED:		BORING LOGS			
DRAWN: GRS		BORING LOGS 73-5M THRU 73-9M & 79-10M			
DESIGNED: JRC/PAW		CAD FILE NAME: CHASKA2.DGN		DRAWING NUMBER:	
CHECKED: JRC/DWM		SPEC NO: DACW37-90-B-0000		SHT 3 OF 14	
DATE: 05-04-91		PLATE C-3			

2



**NOTES:**

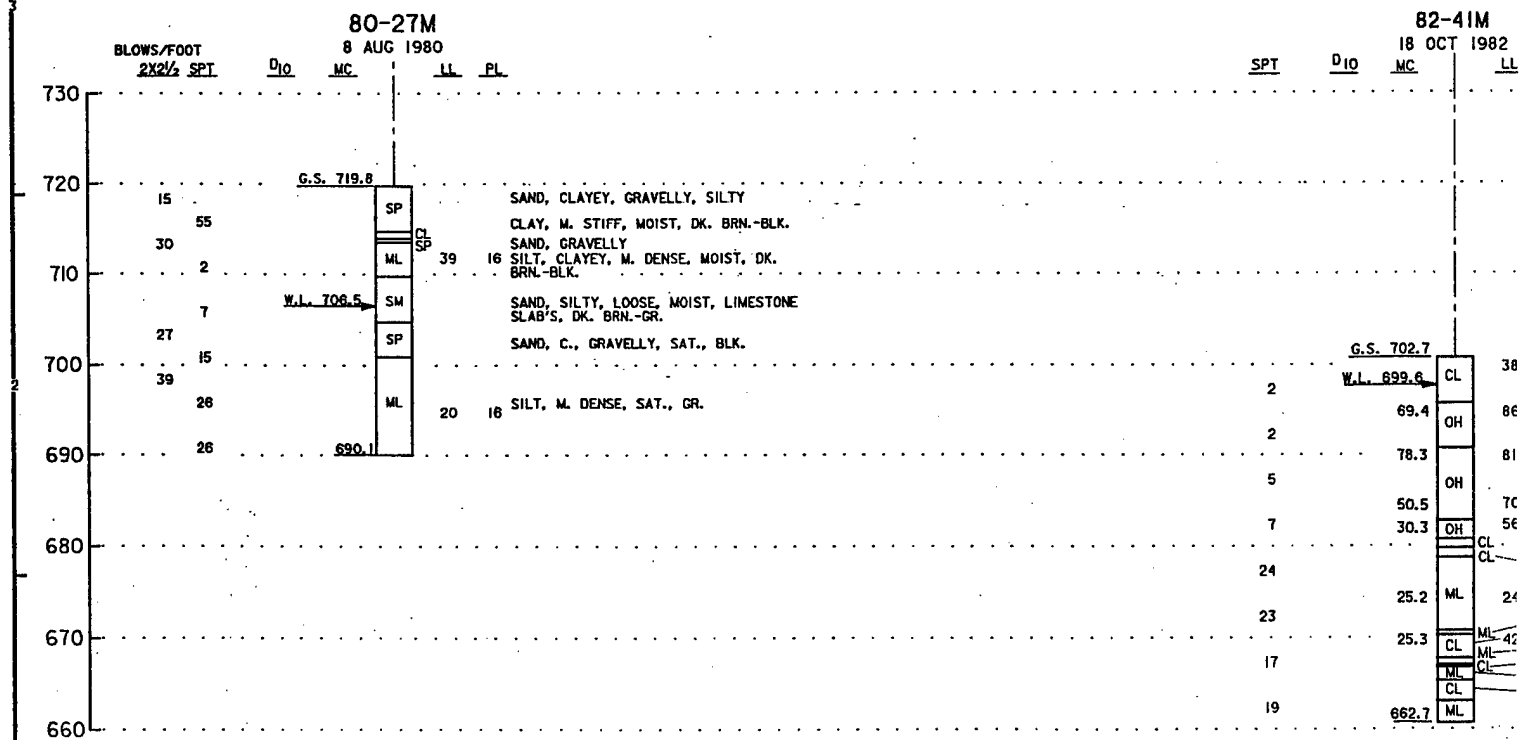
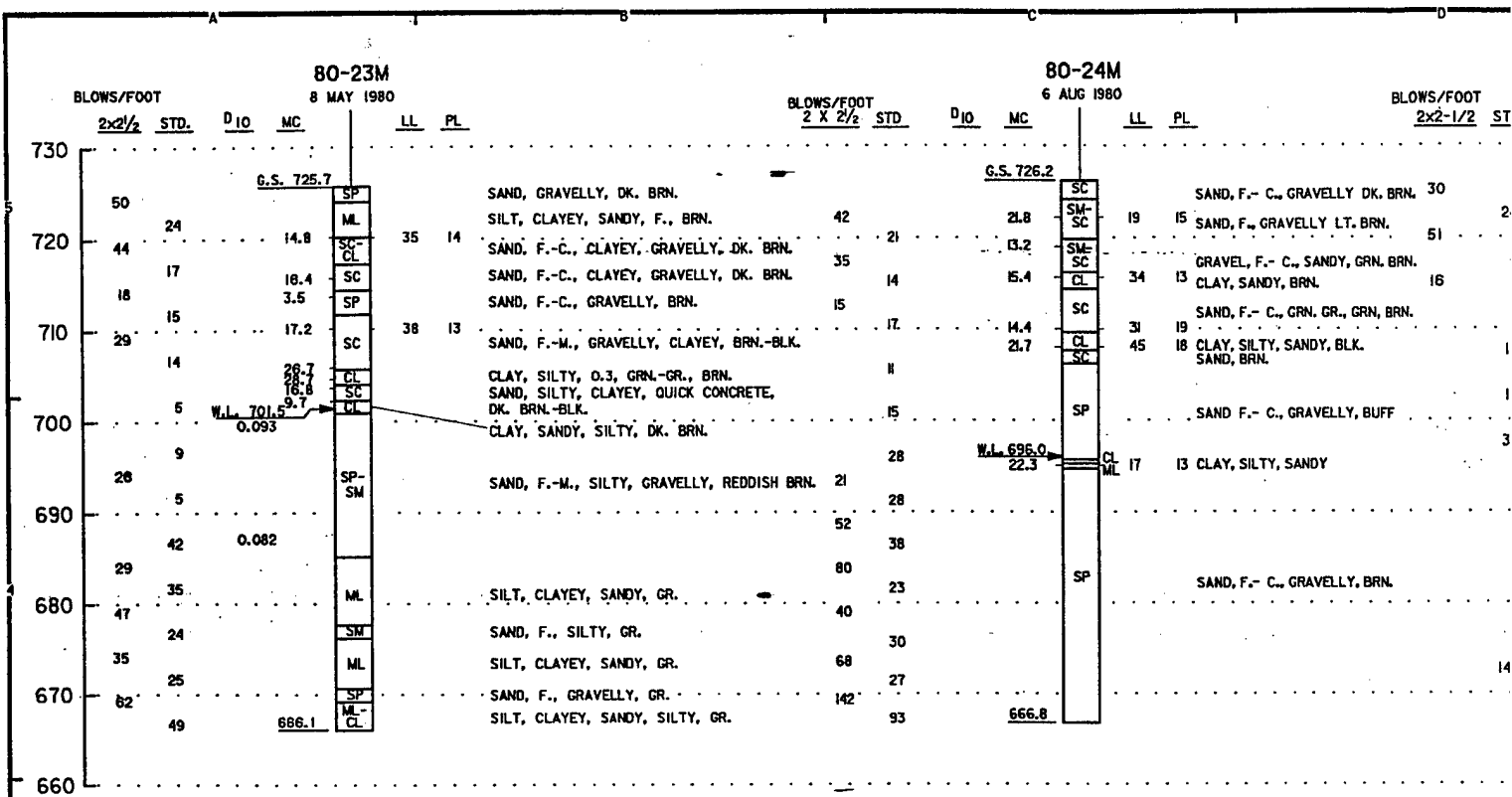
L WATER LEVEL NOT DETERMINED



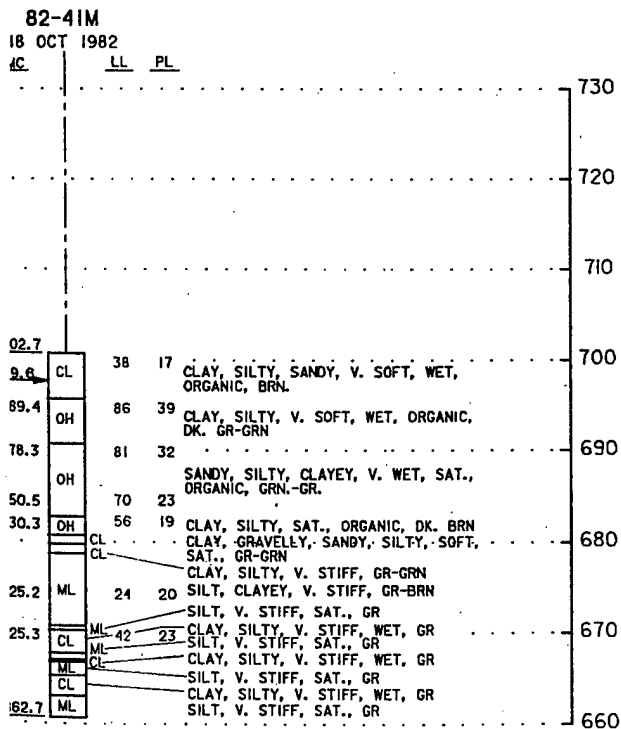
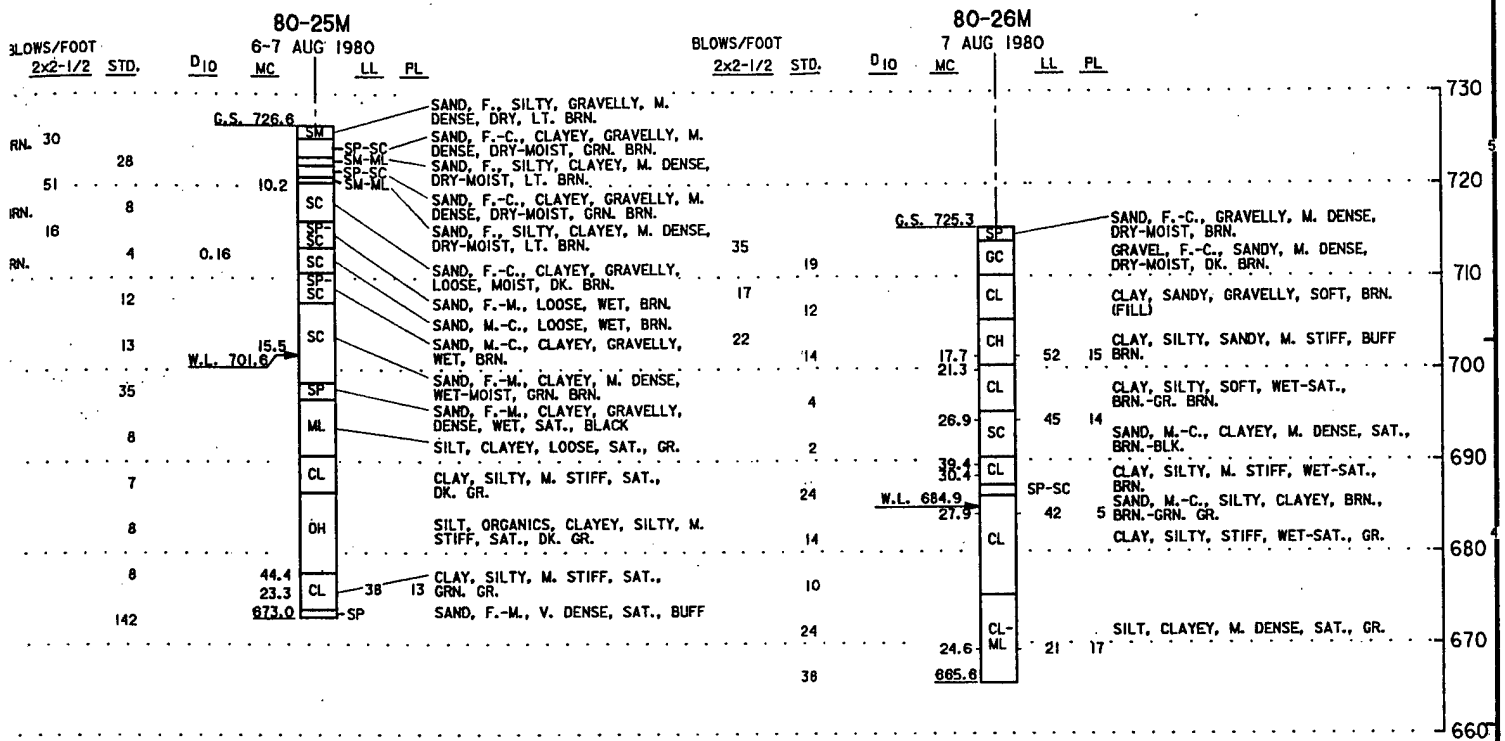
SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p>DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA CREEK STAGE 4 CHASKA, MINNESOTA BORING LOGS BORING LOGS 79-11M THRU 79-16M</p>			
DESIGNED: CHECKED: DRAWN: GRS	DESIGNED: JRC/PAW		CAD FILE NAME: CHASKA3.DGN		DRAWING NUMBER:
	CHECKED: JRC/DWM		DATE: 05-04-91		SHT 4
	SPEC NO: DACW37-90-B-0000		PLATE C-4		OF 14





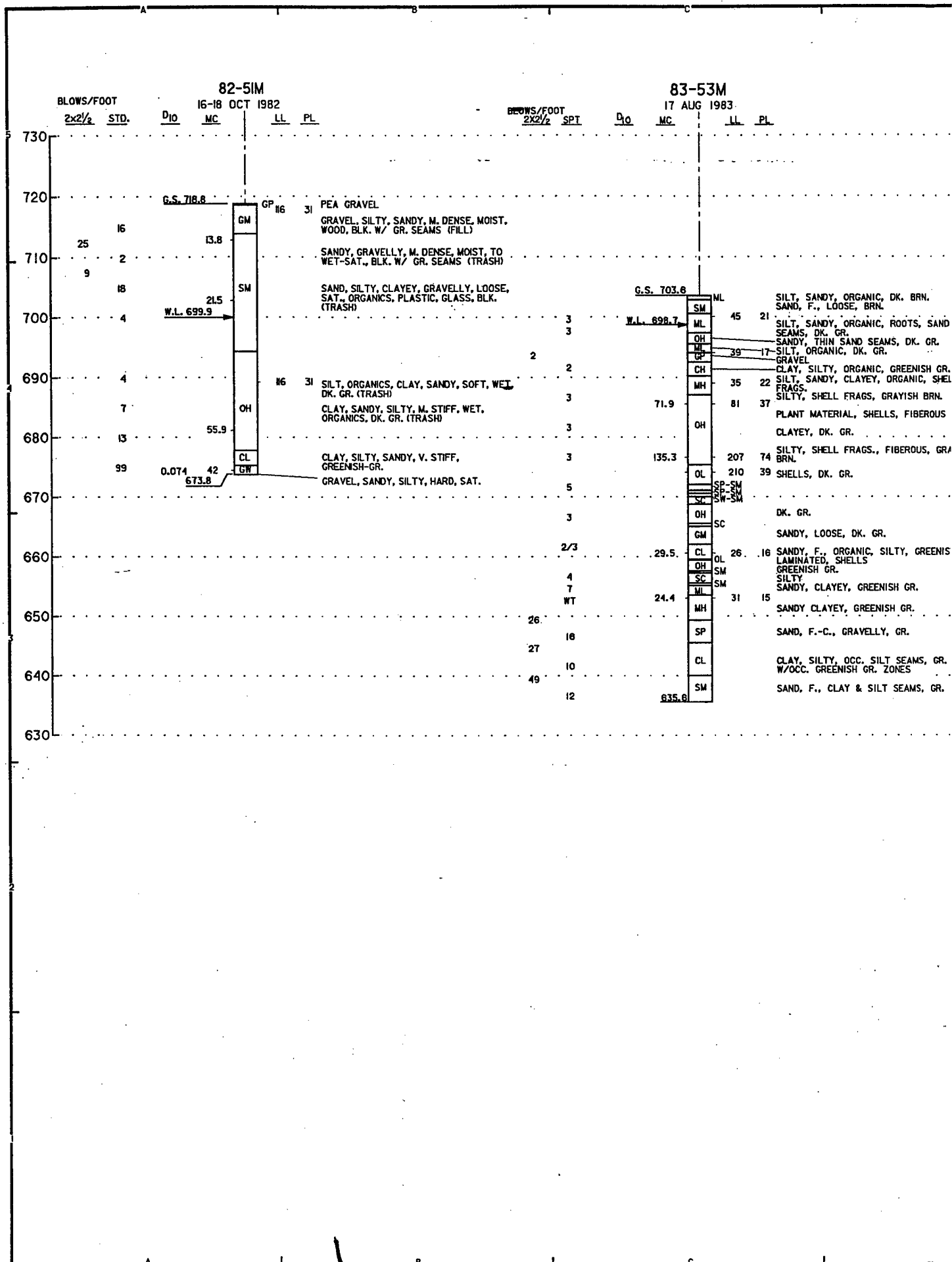


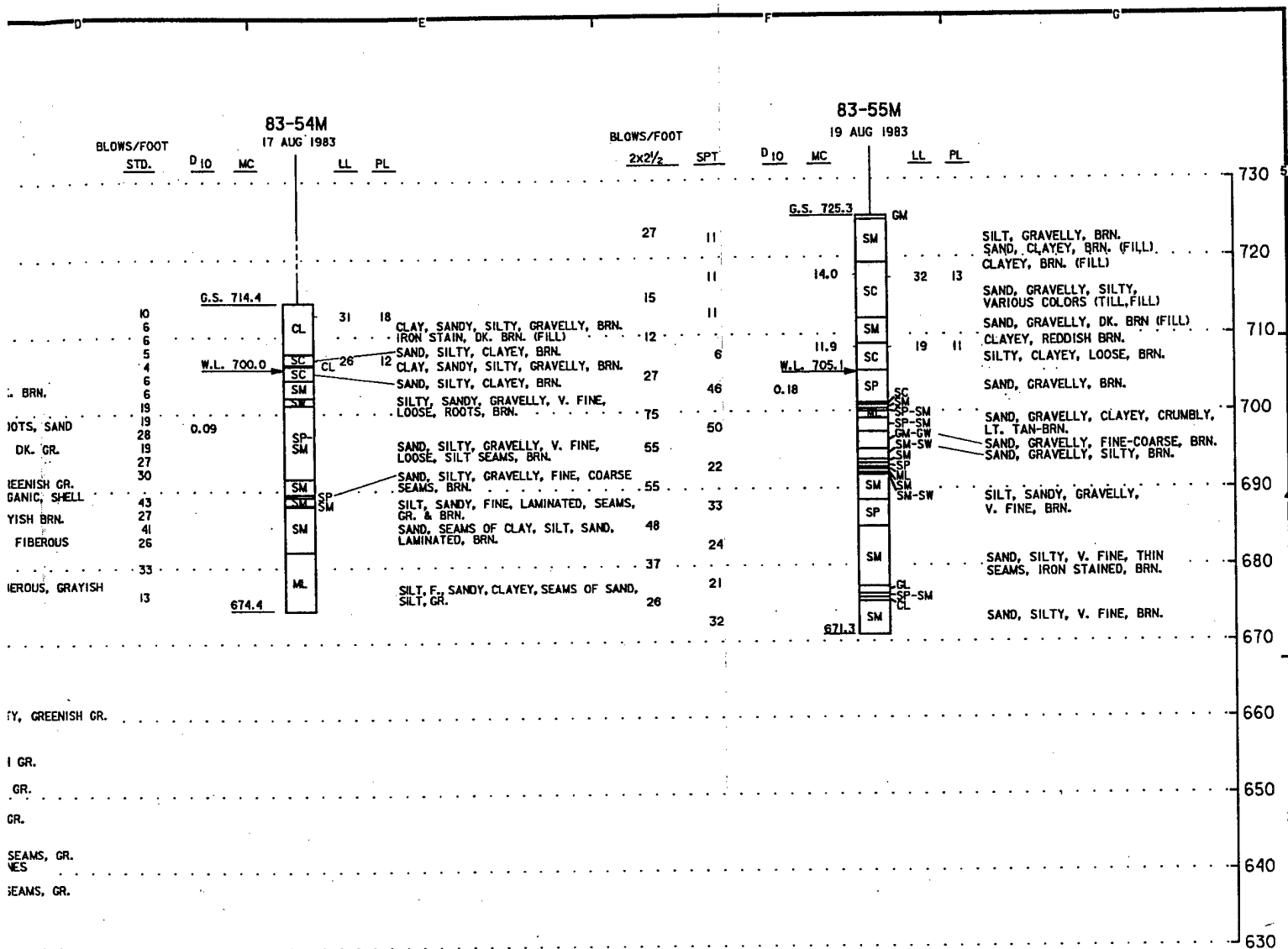




SYMBOL	DESCRIPTION	DATE	APPROVAL
<p><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>AE APPROVING OFFICIAL:</p>		<p>DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA CREEK STAGE 4 CHASKA, MINNESOTA BORING LOGS BORING LOGS 80-23M THRU 80-27M &amp; 82-41M</p>	
DESIGNED:	JRC/PAW	CAD FILE NAME: CHASKA5.DGN	DRAWING NUMBER: SHT 6 OF 14
CHECKED:	JRC/DWM	SPEC NO: DACW37-90-B-0000	<b>PLATE C-6</b>
DRAWN:	GRS		
DATE:	05-04-91		

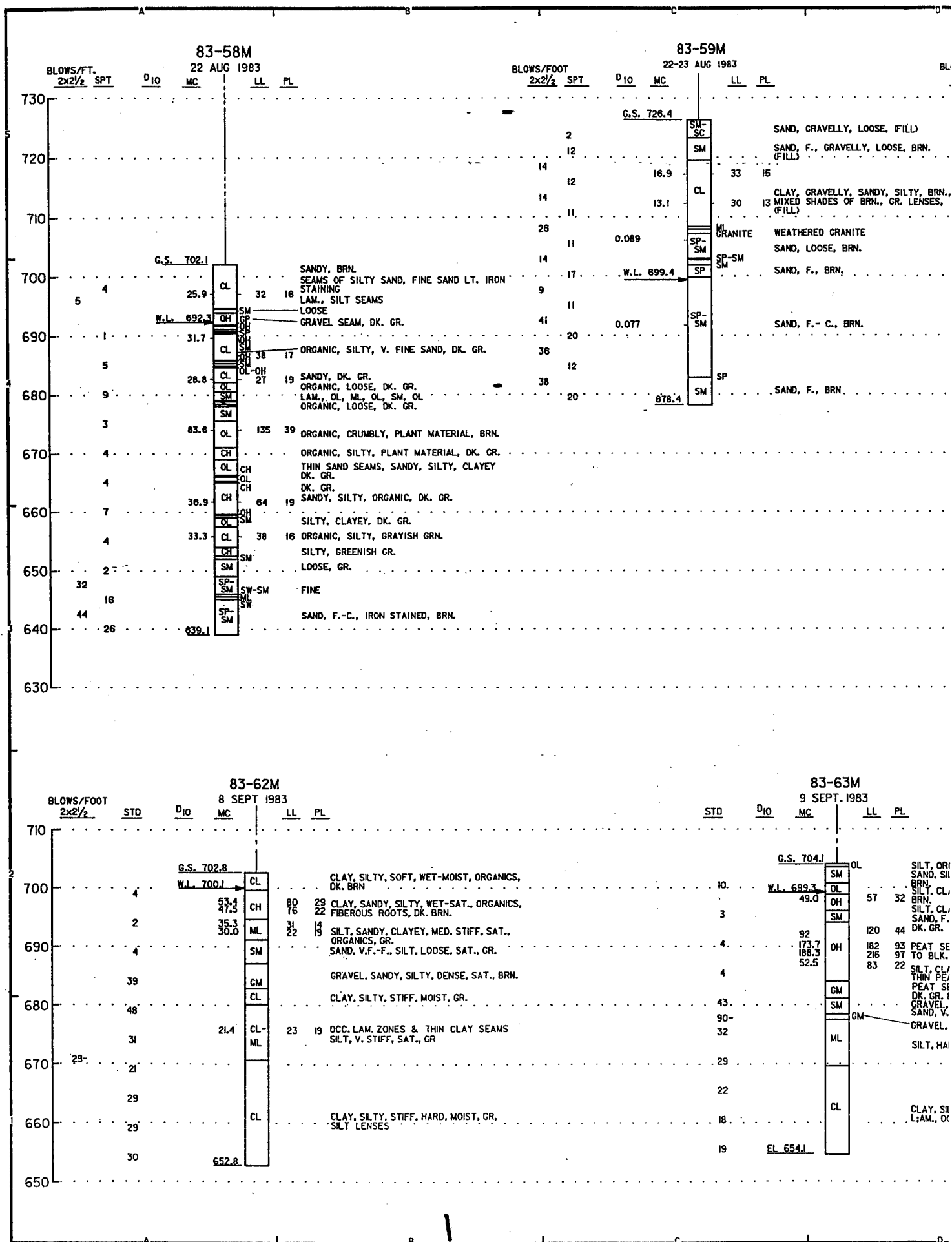
2





Y, GREENISH GR.  
I GR.  
GR.  
GR.  
SEAMS, GR.  
VES  
SEAMS, GR.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER</p>			
DESIGNED:		CHASKA CREEK STAGE 4 CHASKA, MINNESOTA			
CHECKED:		BORING LOGS			
DRAWN: GRS		BORING LOGS 82-51M & 83-53M THRU 83-55M			
DESIGNED: JRC/PAW		DRAWING NUMBER:			
CHECKED: JRC/DWM		CAD FILE NAME: CHASKA6.DGN		SHT 7	
DATE: 05-04-91		SPEC NO: DACW37-90-B-0000		OF 14	
<p align="center"><b>PLATE C-7</b></p>					



## 83-60M

23 AUG 1983

BLOWS/FT.

2x2 1/2 SPT

D10

MC

LL

PL

G.S. 725.9

CM

SC

CL

SM

SC

CL

SM

SM

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GRAVELLY  
GRAVELLY, SANDY, GR. & BRN.  
VERY FINE, LOOSE, BRN.GRAVELLY, SANDY, SILTY, TILL, BROWNISH  
AND GR. (TILL)

SANDY, BRN., ALLUVIUM

GRAVELLY, BRN.  
SEAMS OF COARSE SAND

## 83-61M

24 AUG 1983

STD

D10

MC

LL

PL

G.S. 715.2

0.16

W.L. 709.6

19.9

26.1

28.6

665.2

ML

GW

GM

CL

ML

CL

ML

CL

ML

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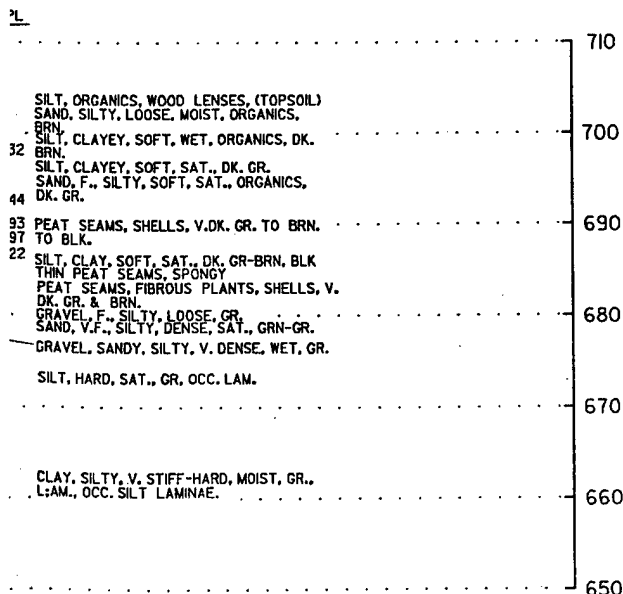
SANDY, SILT, SOFT-MED. STIFF, MOIST,  
ORGANIC, DK. BRN-BLK, (TOPSOIL)GRAVEL, COBBLES, SANDY, SILTY, DENSE,  
MOIST-SAT., BROWNISH

SILT, STIFF, SAT., GR. SOME LAM. ZONES

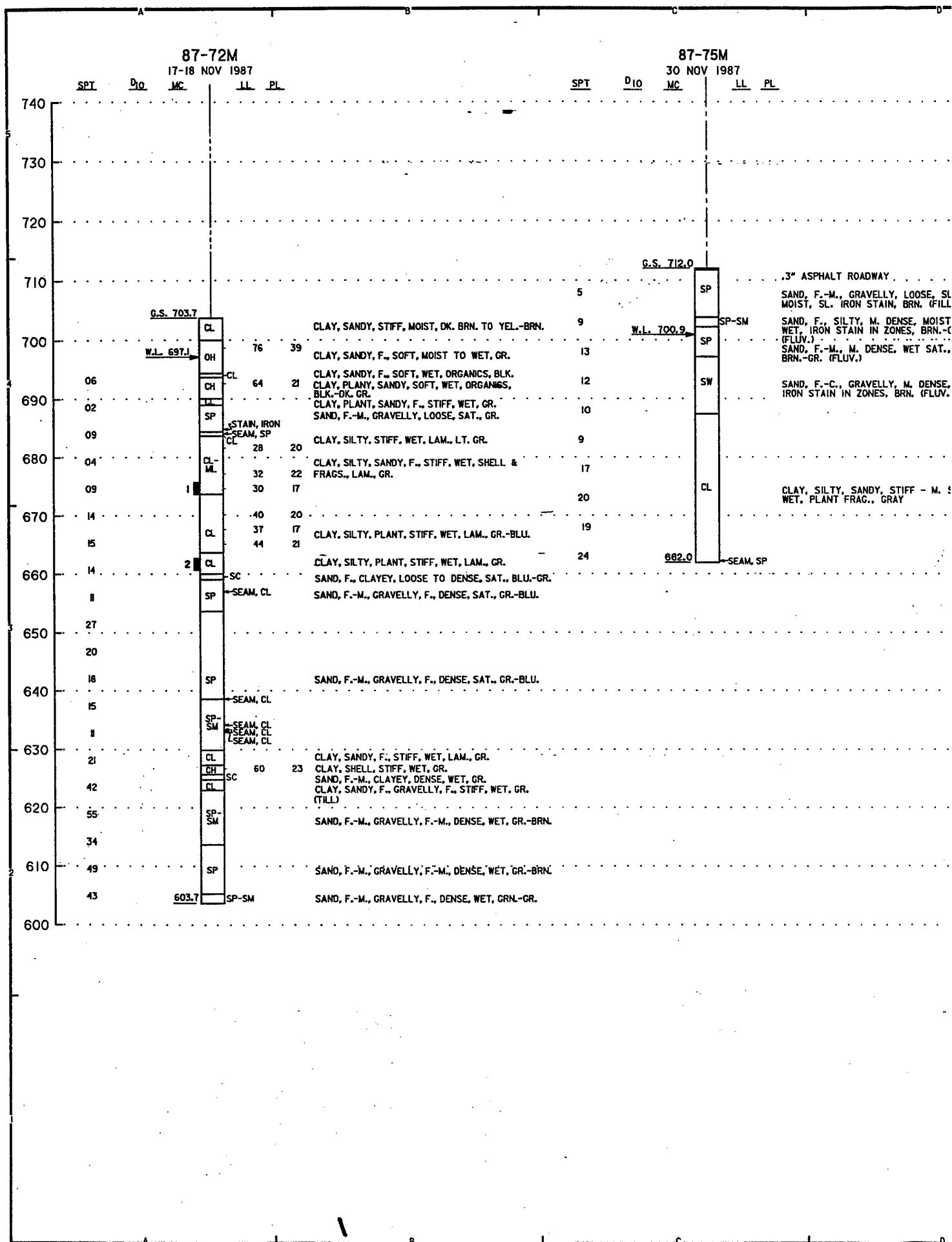
CLAY, SILTY, GR. LAM. ZONES.

CLAY, SILTY, STIFF, MOIST, GR. LAM.,  
SILT LENSES.

SILT, CLAYEY, STIFF, WET, GR.



SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA CREEK STAGE 4 CHASKA, MINNESOTA BORING LOGS BORING LOGS 83-58M THRU 83-63M</p>			
DESIGNED:	CHECKED:	DRAWN:	JRC/DWM	CAD FILE NAME: CHASKA65.DGN	DRAWING NUMBER:
<p align="center">PLATE C-8</p>				SHT 8	OF 14



87-76M

1 DEC 1987

SPT D<sub>10</sub> MC LL PL

G.S. 727.5

15

19

17

19

8

15

20

48

SP

SP

SP

SP

SW

SM

ASPHALT ROADWAY  
SAND, F.-M., GRAVELLY, M. DENSE, MOIST.  
BRN.-DK. BRN. (FILL)

SAND, F.-M., GRAVELLY M. DENSE, MOIST,  
LT. BRN. (FILL)

SAND, F.-M., SILT, M. DENSE, MOIST,  
THINLY LAM., LT. BRN.

SAND, F.-M., M. DENSE, SAT., BRN.

SAND, F., SILTY, DENSE, SAT., BRN.

87-77M

1 DEC 1987

SPT D<sub>10</sub> MC LL PL

G.S. 727.1

5

3

10

12

12

32

34

32

SP

CL

ML

CL

CL-ML

ML

ML

SP

SP-SM

SM

SAND, F.-M., GRAVELLY LOOSE, SL. MOIST,  
OIL STAINED, BLK.  
CLAY, SILTY, SANDY, M. STIFF, MOIST,  
ROOT FRAG., DK. BRN.

CLAY, SILTY, SOFT, WET, V. THINLY LAM.,  
ORANGE - GR.

CLAY, SILTY, M. STIFF, WET, TAN

SILT, CLAYEY, STIFF, WET - SAT., TAN -  
GR.

CLAY, SILTY, (INTERBEDDED), M. STIFF,  
WET LAM., GR.  
SILT, CLAYEY, M. STIFF, WET, LAM., BRN.

SAND, F.-M., M. DENSE, SAT., BRN. - GR.

SAND, F.-M., CLAYEY, M. DENSE, SAT., GR.

720

710

700

690

680

670

660

650

640

630

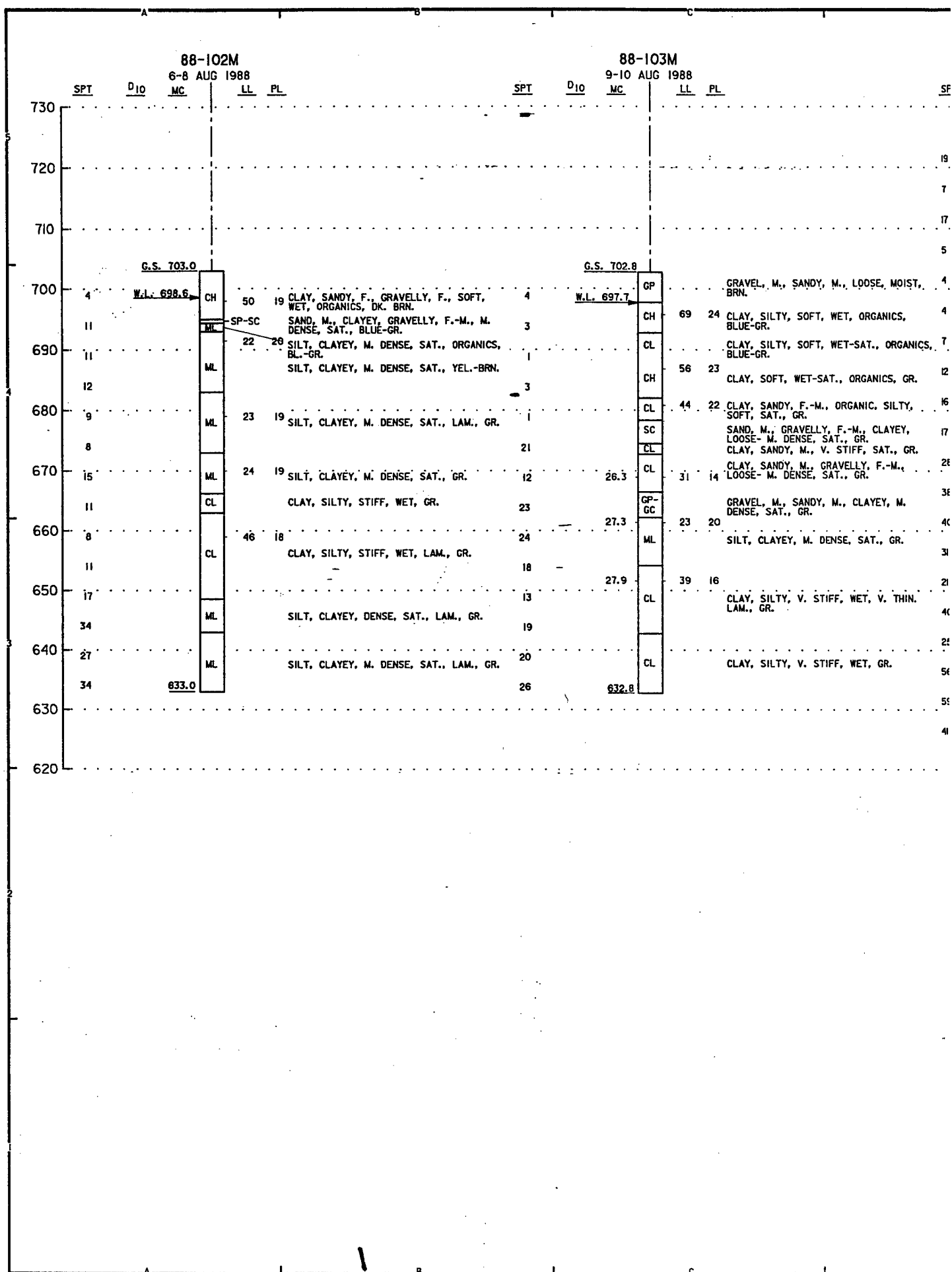
620

610

600

STIFF - M. STIFF,  
AY

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA CREEK STAGE 4 CHASKA, MINNESOTA BORING LOGS BORING LOGS 87-72M, &amp; 87-75M, THRU 87-77M</p>			
ED-D	DESIGNED:				
	CHECKED:				
	DRAWN: GRS				
ED-D	DESIGNED: JRC/PAW				
	CHECKED: JRC/DWM				
DATE: 05-04-91		CAD FILE NAME: CHASKA7.DGN		DRAWING NUMBER:	
		SPEC NO: DACW37-90-B-0000		<p align="center"><b>PLATE C-9</b></p>	





89-106M

26-27 MAY 1989

SPT D10 MC LL PL

G.S. 725.5

19	SM	SAND, F., SILTY, GRAVELLY, MED. DENSE, DRY, RUBBLE, BRN. (FILL)
7	SM	SAND, F., GRAVELLY, LOOSE, DRY TO MOIST, BRN. (FILL)
17	SM	SAND, F., GRAVELLY, RUBBLE, LOOSE TO MED. DENSE, DRY TO MOIST, BRN. TO BLK. (FILL)
5		
4	SP-SM	SAND, F., GRAVELLY, LOOSE, MOIST TO WET, BRN. TO GRAY
4	ML	SLT, CLAYEY, SOFT, WET, ORGANICS, BLK.
CS, 7		
12	CH	CLAY, SILTY, MED. STIFF TO STIFF, MOIST, ORGANICS, BLK.
16	CL	CLAY, SILTY, SANDY, STIFF, WET, BLK.
17	SP	SAND, F., GRAVELLY, MED. DENSE, WET, GR. TO BRN.
28		
38		
40	SW	SAND, F. TO M., GRAVELLY, DENSE, WET, GR. TO BRN.
31		
21	SP	SAND, F. TO M., GRAVELLY, MED. DENSE TO DENSE, WET, BRN.
40		
25	SP	SAND, F. TO C., SILTY, MED. DENSE TO V. DENSE, WET, BRN.
56		
59	SP	SAND, M., GRAVELLY, V. DENSE, WET, BRN.
41	SW	SAND, F., GRAVELLY, V. DENSE, WET, SL. IRON STAIN, BRN.
		SAND, F. TO M., GRAVELLY, DENSE, WET, BRN.

0.08  
W.L. 698.6

625.5

89-110M

13 JUN 1989

SPT D10 MC LL PL

G.S. 726.6

15	SM	SAND, F., SILTY, CLAYEY, GRAVELLY, MED. DENSE, MOIST, BRN. (FILL)
10	ML	ML-22 18 22 12 ML-18 16 CL-28 16
6	SM	SLT, SANDY, CLAYEY, STIFF, MOIST, BRN. MOIST, BRN. TO GRAY
9	SC	CLAY, CLAYEY, SANDY, GRAVELLY, STIFF, MOIST, BRN.-GRAY
15	CL	SAND, F., SILTY, GRAVELLY, LOOSE, MOIST, BRN.
8	OL	CLAY, SILTY, SANDY, STIFF, MOIST, BRN.
9	CL	CLAY, SILTY, CLAYEY, GRAVELLY, STIFF, MOIST, SL. ORGANICS, BRN.-GRAY, BLK.
9	OL	CLAY, SANDY, SILTY, GRAVELLY, STIFF, MOIST, ORGANICS, BRN.-GRAY, BLK.
9	OL	SEAM, SC OL 38 19
9	OL	SLT, STIFF, MOIST, SL. SOLVENT ODER, ORGANICS, GRAY TO BLK.
14	CL	CLAY, SILTY, STIFF, MOIST TO WET, ORGANICS, GRAY
22	SP	CLAY, SILTY, STIFF, MOIST, ORGANICS, GRAY
34	SP	CLAY, SILTY, STIFF, MOIST, ORGANICS, GRAY
		CLAY, SILTY, STIFF, MOIST, ORGANICS, GRAY
		CLAY, SILTY, PEAT, STIFF, MOIST, BLK.
		CLAY, SILTY, STIFF, MOIST, PEAT, BLK.
		CLAY, SILTY, V. STIFF, MOIST, LT. GRAY
		SAND, F., GRAVELLY, MED. DENSE, SAT., BRN.
		SAND, F. TO M., GRAVELLY, MED. DENSE, WET, BRN.

W.L. 687.0

666.6

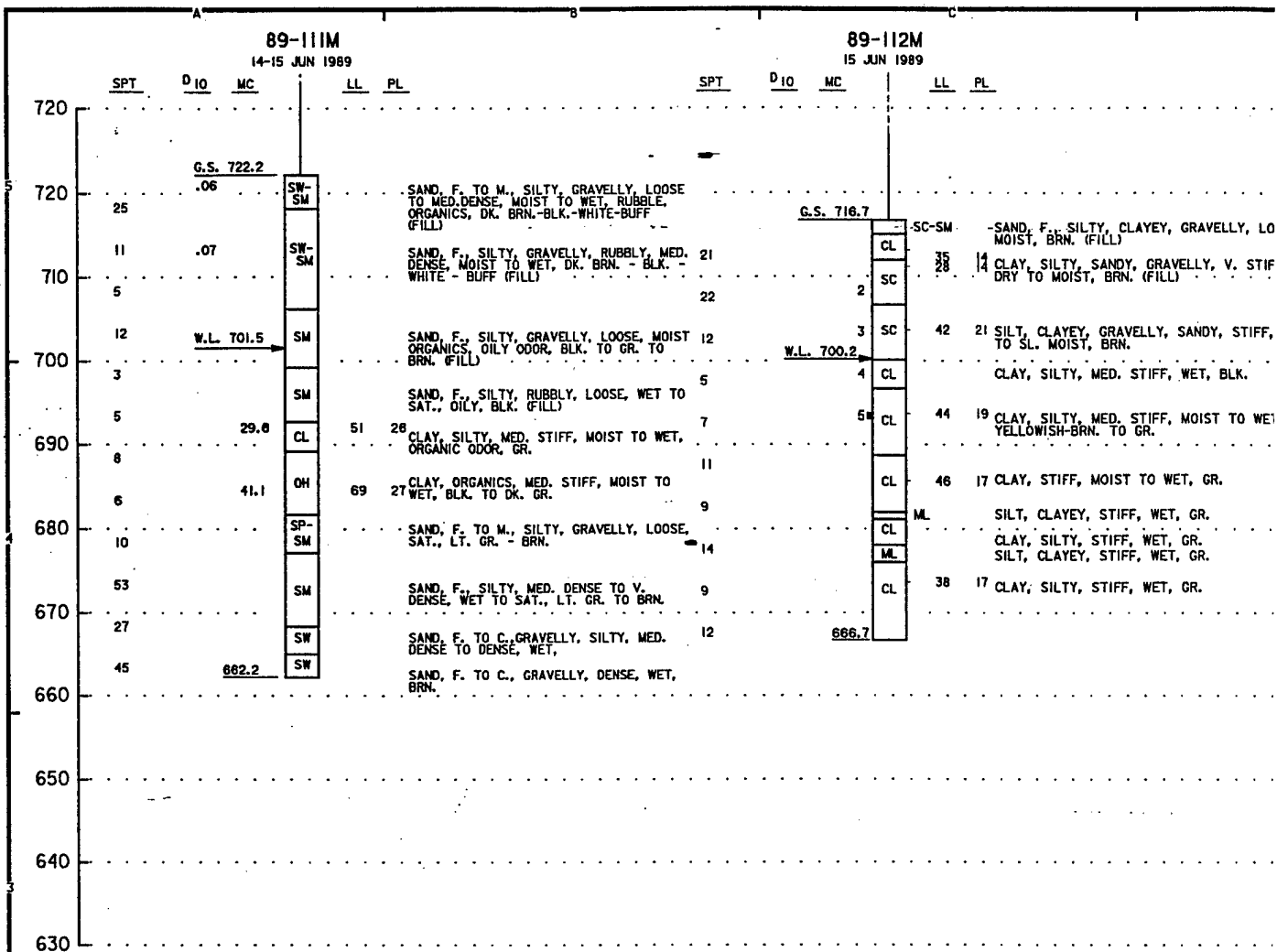
## NOTES:

1. WATER LEVEL DETERMINED AFTER 30 MINUTES WITH:  
BOTTOM OF HSA AT EL. 686.5  
BOTTOM OF HOLE AT EL. 689.5  
AFTER SAMPLING TO EL. 685.5
2. HSA ADVANCED TO EL. 686.5 AND DRILLING MUD USED BELOW.
3. WATER LOSS WHILE ADVANCING HOLE VARIED BETWEEN 0 AND 20 GPM BELOW EL. 686.5.
4. HOLE BACKFILLED WITH TREMED CEMENT-BENTONITE GROUT.

## NOTES:

1. WATER LEVEL DETERMINED AFTER 2 HOURS WITH:  
BOTTOM OF AUGER AT EL. 676.6  
BOTTOM OF HOLE AT EL. 680.2  
AFTER SAMPLING TO EL. 676.6
2. HOLLOW STEM AUGER SET TO EL. 672.6. HOLE STABILIZED WITH DRILLING MUD FROM EL. 672.6 TO EL. 666.6.
3. WATER LOSS BETWEEN EL. 672.6 AND 676.6 = 5 GPM.
4. TWO - 5' UNDISTURBED SAMPLES TAKEN IN AN OFFSET HOLE AT EL. 705.6 AND AT EL. 695.6.
5. HOLE BACKFILLED WITH TREMED CEMENT-BENTONITE GROUT, BEFORE CASING WAS PULLED.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER</p>			
DESIGNED:		CHASKA CREEK STAGE 4 CHASKA, MINNESOTA			
CHECKED:		BORING LOGS			
DRAWN: GRS		BORING LOGS 88-102M, 88-103M, 89-106M, & 89-110M			
DESIGNED: JRC/PAW		CAD FILE NAME: CHASKA8.DGN		DRAWING NUMBER:	
CHECKED: JRC/DWM		SPEC NO: DACW37-90-B-0000		SHT 10	
DATE: 05-04-91		PLATE C-10		OF 14	



#### NOTES:

1. WATER LEVEL DETERMINED AFTER 17 HOURS WITH:  
BOTTOM OF AUGER AT EL. 697.2.  
BOTTOM OF HOLE AT EL. 696.9  
AFTER SAMPLING TO EL. 692.2.
2. HSA SET TO EL. 693.2. HOLE STABILIZED WITH DRILLING MUD BELOW 693.2'
3. WATER LOSS BELOW 693.2 WAS BETWEEN 1 AND 5 GPM
4. FOUR-3 INCH SHELBY TUBE UNDISTURBED SAMPLES TAKEN IN AN OFFSET HOLE.

#### NOTES:

1. WATER LEVEL DETERMINED AFTER 1 HOUR.  
BOTTOM OF AUGER AT EL. 701.7.  
BOTTOM OF HOLE AT EL. 699.4.  
AFTER SAMPLING TO EL. 696.7.
2. HOLLOW STEM AUGER SET TO ELEVATION 697.7. HOLE STABILIZED WITH DRILLING MUD BELOW ELEVATION 697.7.
3. NO WATER LOSS BELOW EL. 697.7.
4. FIVE -5" UNDISTURBED SAMPLES TAKEN IN AN OFFSET HOLE.
5. BACKFILLED HOLE WITH TREMIED CEMENT-BENTONITE GROUT.

16 JUN 1989

C	I	LL	PL
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SPT	D <sub>10</sub>	MC	I	LL	PL
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89-114M

16-17 JUN 1989

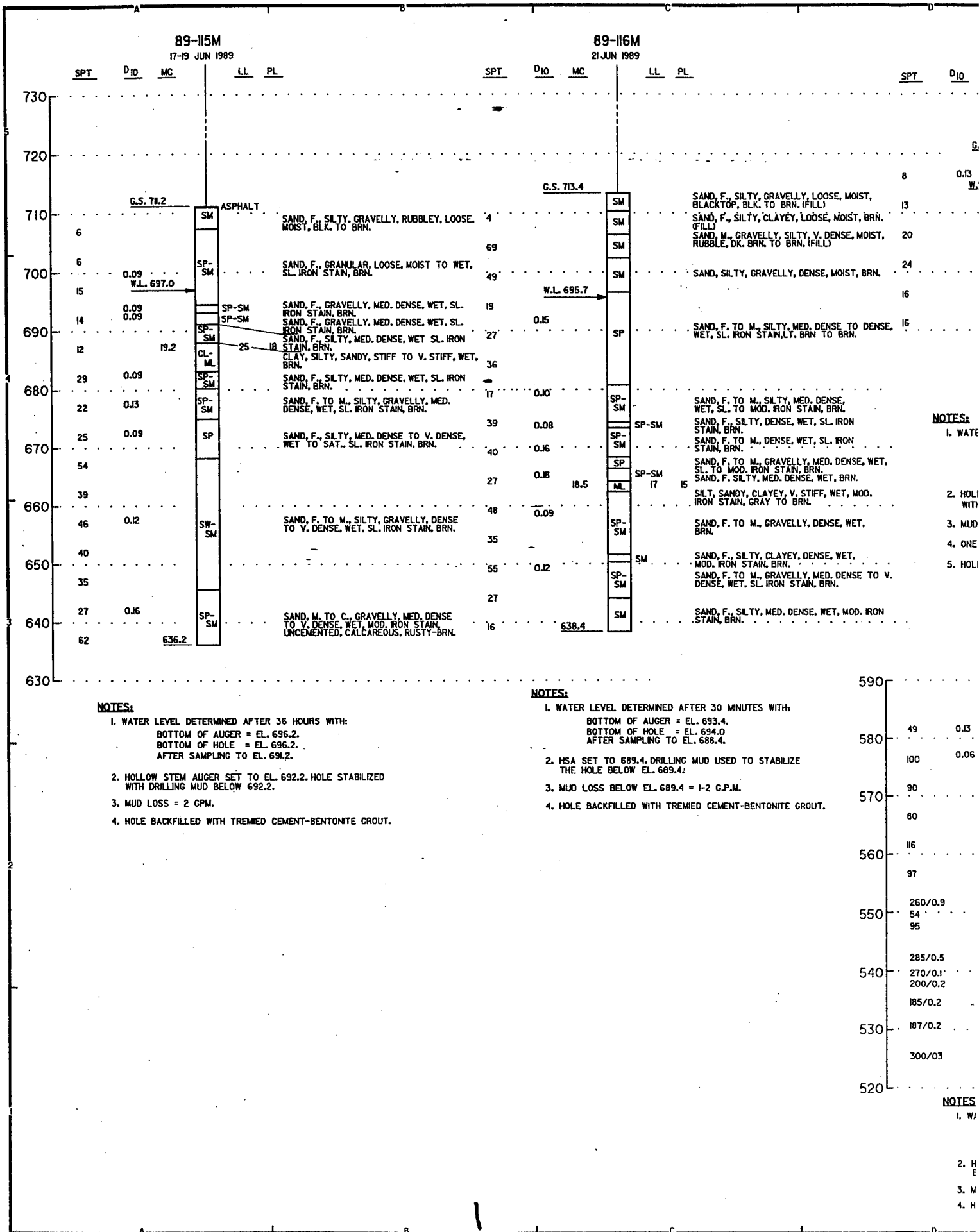
SPT	D <sub>10</sub>	MC	LL	PL
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	G.S. 717.8	ASPHALT			G.S. 711.7	ASPHALT SC-SM			
LOOSE,							SAND, F., CLAYEY GRAVELLY, SILTY, LOOSE, MOIST, BLK. (FILL)		
TIFF,									
	13								
	8	SP-SM	SAND, F., GRANULAR, LOOSE TO MED. DENSE, MOIST, NONCALCAREOUS, BRN.	9	0.13				
FF, DRY	5			6		SP	SAND, F., LOOSE, MOIST, SL. IRON STAIN, BRN.		
	13								
	W.L. 696.7	SP	SAND, F., MED. DENSE, MOIST, SL. CALCAREOUS	10	W.L. 696.7				
WET,	27	0.16	SP	SAND, V. F., MED. DENSE, WET TO SAT., CALCAREOUS, BRN.	18	0.07	SP-SM	SAND, F., SILTY, MED. DENSE, MOIST TO WET, BRN.	
	29	0.12	SP	SAND, F. TO M., MED. DENSE, WET TO SAT., CALCAREOUS	13	0.12	SP-SM	SAND, F. TO M., GRAVELLY, MED. DENSE, WET TO SAT., BRN.	
	25		SP	SAND, F. TO M., MED. DENSE, WET, CALCAREOUS, SL. IRON STAIN, UNCEMENTED, BRN.	13	0.10	SP-SM	SAND, F., MED. DENSE, WET TO SAT., MOD. IRON STAIN, BRN.	
	33	0.12	SP-SM	SAND, F., SILTY, MED. DENSE, WET, SL. IRON STAIN, UNCEMENTED, CALCAREOUS, BRN.	13	0.11	SP-SM	SAND, F. TO M., GRAVELLY, MED. DENSE, SL. IRON STAIN, BRN.	
	25	0.122	SP-SM	SAND, F., SILTY, MED. DENSE, WET, SL. IRON STAIN, UNCEMENTED, CALCAREOUS, BRN.	30	0.08	SP-SM	SAND, F., SILTY, MED. DENSE, WET TO SAT., SL. IRON STAIN, BRN.	
	63			29	0.11	SP-SM	SAND, M. TO C., GRAVELLY, MED. DENSE, WET, SL. IRON STAIN, BRN.		
	42	0.16	SP-SM	SAND, F. TO M., GRAVELLY, SILTY, MED. DENSE TO V. DENSE, WET, UNCEMENTED, CALCAREOUS, BRN.	42				
	24			50	0.16	SP-SM	SAND, F. TO M., GRAVELLY, DENSE, WET, SL. IRON STAIN, BRN.		
	50			36					
	53	0.10	SP-SM	SAND, F., SILTY, V. DENSE, WET, SL. CALCAREOUS, BRN.	38	0.09	SP-SM	SAND, F., GRAVELLY, DENSE, WET, SL. IRON STAIN, BRN.	
	45	0.15	SP-SM	SAND, F. TO M., DENSE, WET, UNCEMENTED, SL. CALCAREOUS, MOD. IRON STAIN, BRN. TO ORANGE	41	0.04	SW-SM	SAND, F. TO M., GRAVELLY, DENSE, WET, SL. IRON STAIN, BRN.	
	842.8			45	0.09	636.7	SW-SM	SAND, M., GRAVELLY, DENSE, WET, MOD. TO HIGH IRON STAIN, BRN. TO ORANGE	

**NOTES:**

1. WATER LEVEL DETERMINED AFTER 15 HOURS WITH:  
BOTTOM OF AUGER AT EL. 691.7.  
BOTTOM OF HOLE AT EL. 693.6.  
AFTER SAMPLING TO EL. 686.7.
2. HOLLOW STEM AUGER ADVANCED TO EL. 687.7 AND  
DRILLING MUD USED TO STABILIZE HOLE BELOW 687.7.
3. WATER LOSS BETWEEN EL. 687.7 AND BOTTOM OF HOLE  
= APPROXIMATELY 2 G.P.M.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

[illegible]

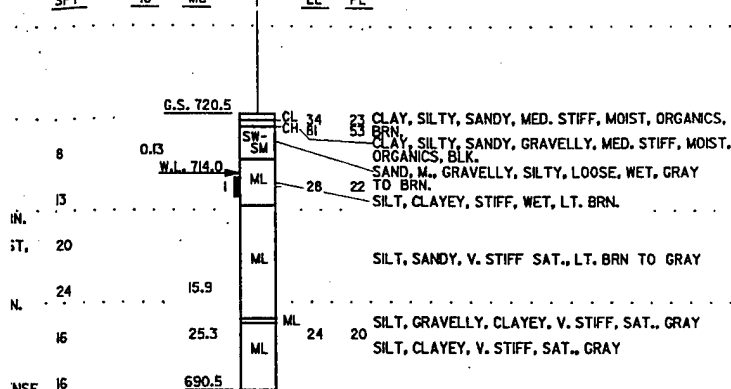


**NOTES:**

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22 JUN 1989

SPT	D <sub>10</sub>	MC	I	LL	PI
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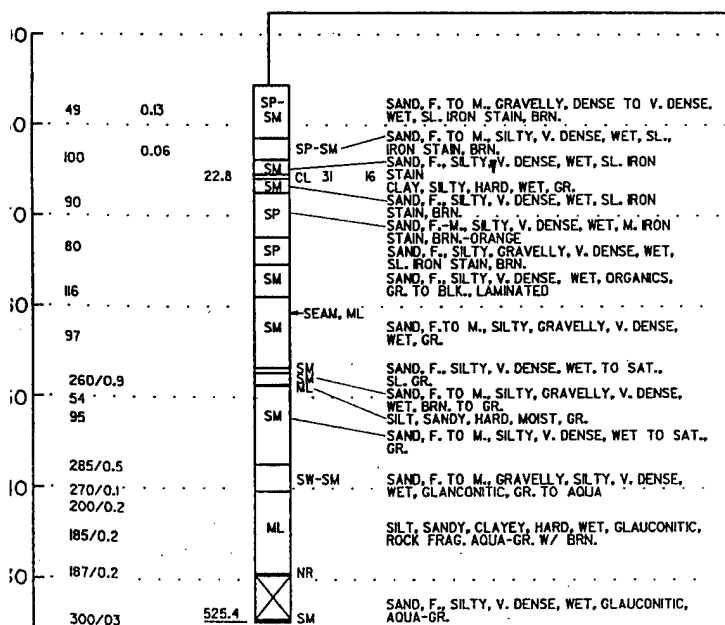


**NOTES:**

1. WATER LEVEL DETERMINED AFTER 30 MINUTES WITH:  
BOTTOM OF AUGER AT EL. 71Q.5.  
BOTTOM OF HOLE AT EL. 71L.2.  
AFTER SAMPLING TO EL. 70S.5.
2. HOLLOW STEM AUGER SET TO EL. 706.5. HOLE STABILIZED WITH BENTONITE DRILLING MUD BELOW EL. 706.5.
3. MUD LOSS BELOW EL. 706.5 = 0 G.P.M.
4. ONE - 5' TUBE SAMPLE TAKEN FROM EL. 713.5 TO EL. 71L.5.
5. HOLE BACKFILLED WITH CEMENT-BENTONITE GROUT.

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ON



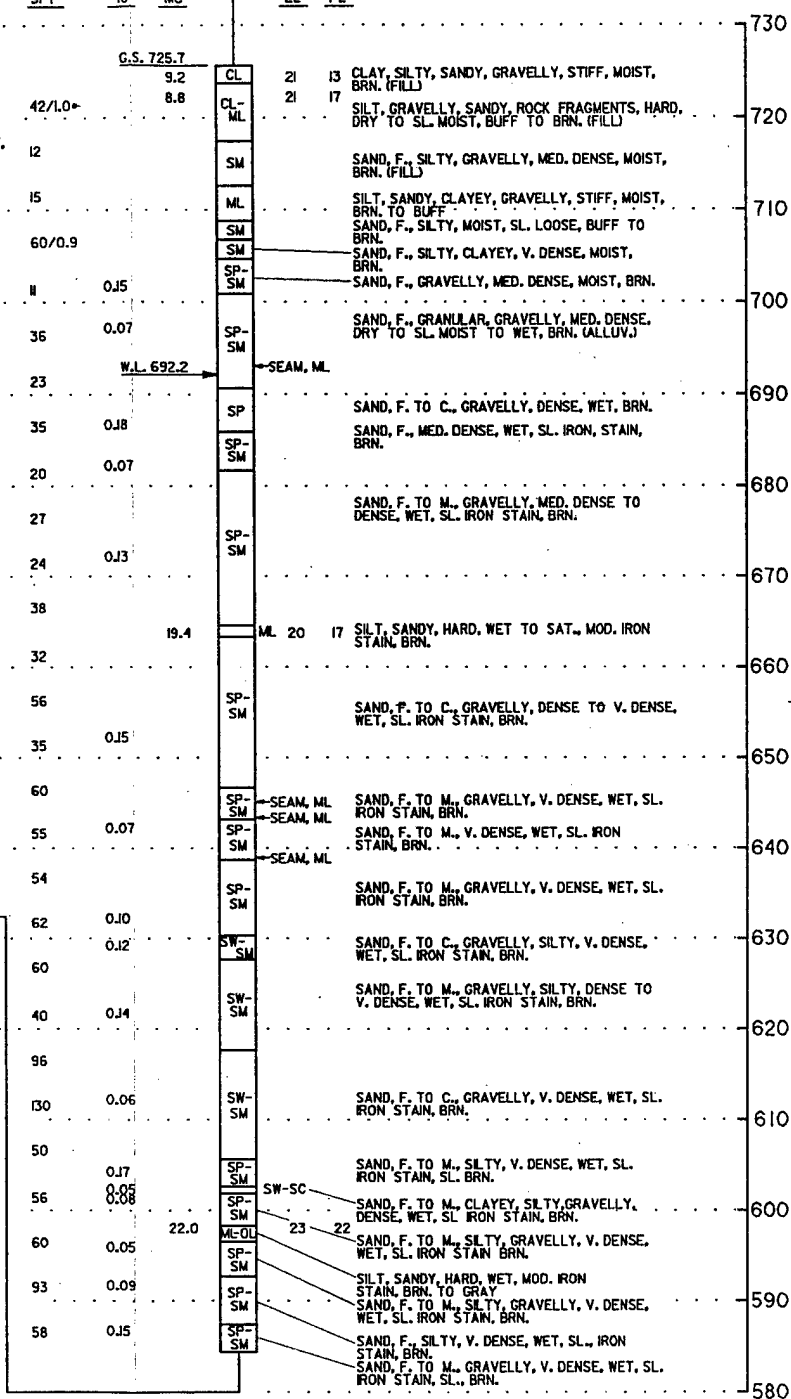
**NOTES:**

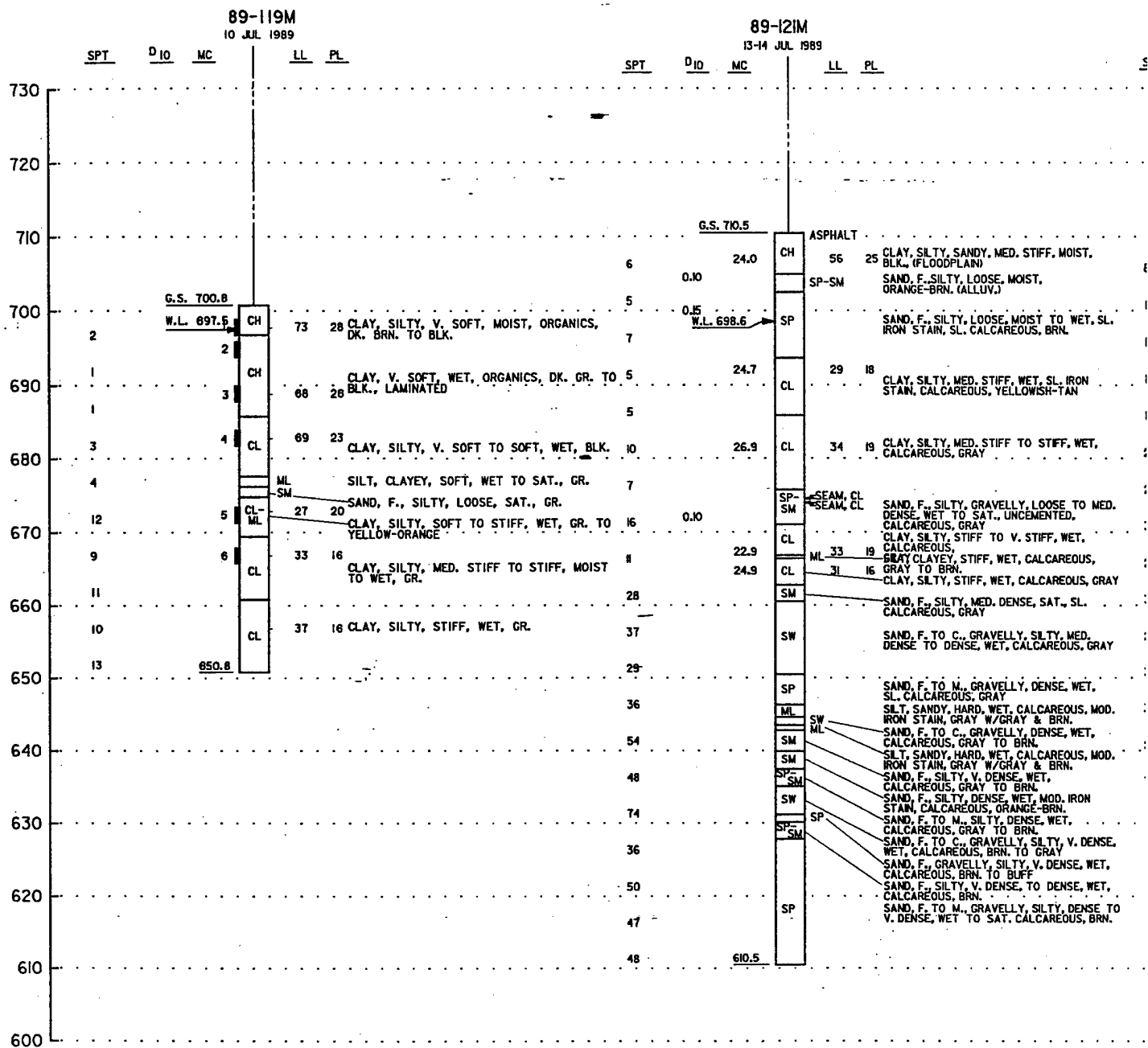
1. WATER LEVEL DETERMINED AFTER 90 MINUTES WITH:  
BOTTOM OF AUGER = EL. 690.7  
BOTTOM OF HOLE = EL. 691.0  
AFTER SAMPLING TO EL. 685.7.
2. HSA SET TO 686.7, HOLE STABILIZED WITH  
BENTONITE DRILLING MUD BELOW EL. 686.7.
3. MUD LOSS BETWEEN LAND 5 G.P.M. BELOW EL. 686.7.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

89-118M

26 JUN - 1 JUL 1989

SPT	D <sub>10</sub>	MC	LL	PL
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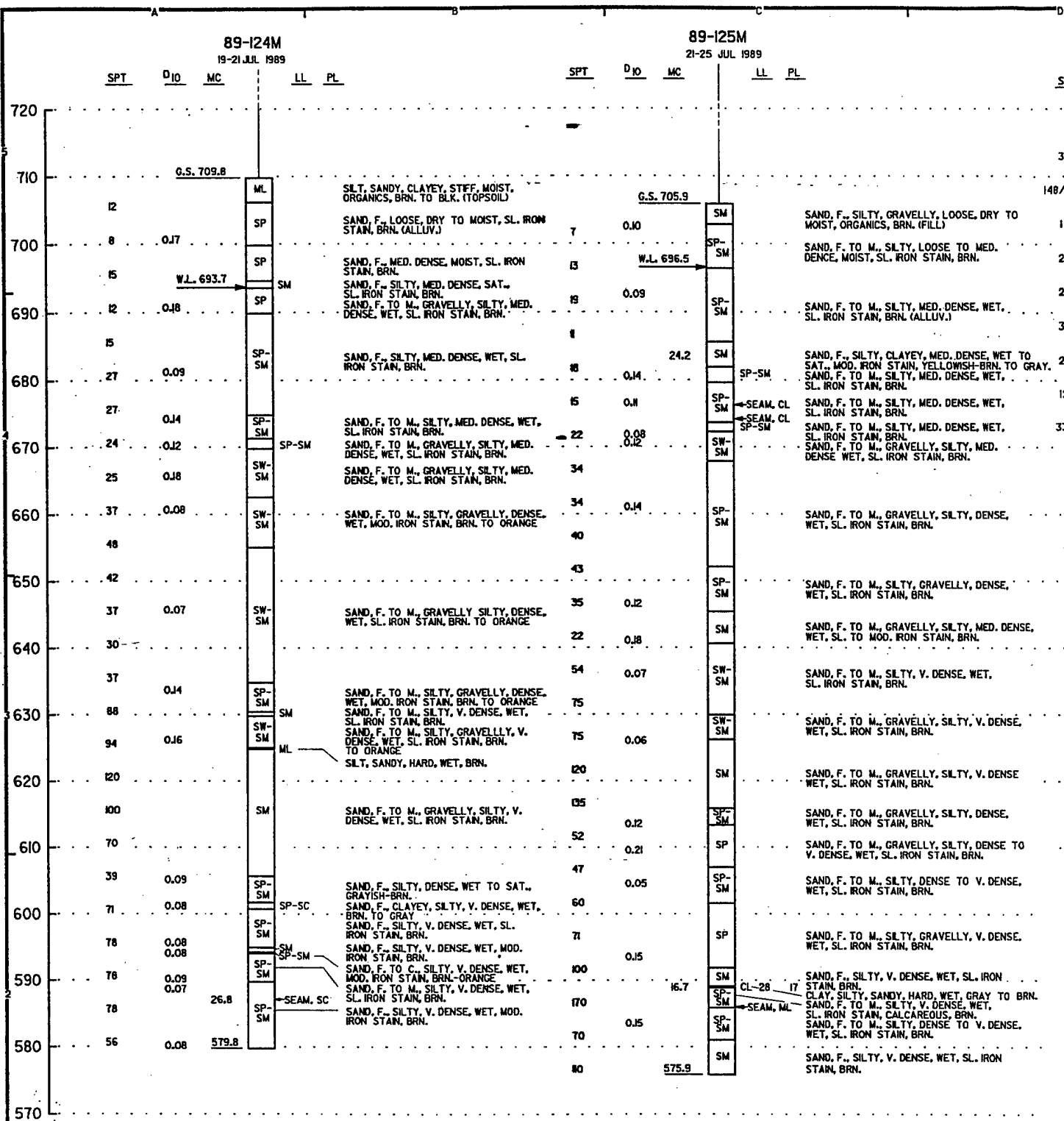
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# **NOTES:**

1. WATER LEVEL DETERMINED AFTER 2 HOURS WHEN:  
BOTTOM OF AUGER AT EL. 695.8.  
BOTTOM OF HOLE AT EL. 694.5.  
AFTER SAMPLING TO EL. 690.8.
2. HOLLOW STEM AUGER SET TO EL. 691.8. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 691.8.
3. WATER LOSS BELOW EL. 691.8 = 1 G.P.M.
4. SIX- 5" UNDISTURBED TUBE SAMPLES TAKEN IN AN OFFSET HOLE.
5. BOTH HOLES BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.





#### NOTES:

1. WATER LEVEL DETERMINED AFTER 1 HOUR WITH BOTTOM OF AUGER AT EL. 694.8  
BOTTOM OF HOLE AT EL. 693.4  
AFTER SAMPLING TO 689.8
2. HOLLOW STEM AUGER SET TO EL. 690.8. HOLE STABILIZED WITH DRILLING MUD BELOW 690.8.
3. WATER LOSS BELOW 690.8 - 2-6 GPM; 20 GPM BETWEEN EL. 614.8 AND EL. 613.8.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

#### NOTES:

1. WATER LEVEL DETERMINED AFTER 90 MINUTES WITH BOTTOM OF AUGER AT EL. 695.9  
BOTTOM OF HOLE AT EL. 696.1  
AFTER DRIVING SAMPLE TO EL. 690.9
2. HSA SET TO EL. 694.9. HOLE STABILIZED WITH DRILLING MUD BELOW 695.5.
3. WATER LOSS BELOW 694.9: 2-5 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



89-126M

26 JUL 1989

SPT D10 MC LL PL

G.S. 707.0

W.L. 701.2

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SAND, F. SILTY, CLAYEY, RUBBLY,  
LOOSE, MOIST, BRN. TO BLK. (FILL)  
SAND, F. SILTY, LOOSE, MOIST,  
BRN. (FILL)  
CLAY, SOFT, WET, GRAY  
SAND, F. TO M. SILTY, GRAVELLY,  
LOOSE, WET, DK. BRN.  
SAND, F. TO M. CLAYEY, SILTY,  
RUBBLY, LOOSE TO V. DENSE, SAT.,  
ORANGE TO WHITE (FILL)

CLAY, SILTY, V. SOFT TO SOFT, WET,  
ORGANICS, BLK. (FLOODPLAIN)

CLAY, SILTY, SOFT, WET, ORGANICS,  
GRAY TO GREENISH-GRAY

SAND, F. TO M. GRAVELLY, SILTY,  
MED. DENSE TO DENSE, SAT., BRN.

89-130M

8-9 AUG 1989

SPT D10 MC LL PL

G.S. 705.1

W.L. 701.0

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SILT, CLAYEY, SOFT, MOIST TO DRY,  
ORGANICS, BRN. TO GRAY, (TOPSOIL)  
SAND, F. SILTY, GRAVELLY, LOOSE, DRY, BRN.

CLAY, SILTY, SOFT, MOIST, ORGANICS, ORGANIC  
ODOR, DK. GRAY TO BLK. (ALLUV.)  
SAND, F. TO M. SILTY, LOOSE, SAT.,  
ORGANICS, GRAY  
CLAY, SOFT, WET, ORGANICS, ORGANIC ODOR,  
DK. GRAY TO BLK.  
CLAY, SILTY, MED. STIFF, WET, GRAY TO BLK.  
GRAVEL, F. TO C., ROUNDED, SANDY, SILTY  
MED. DENSE, WET, RUST (ALLUV.).

SILT, CLAYEY, STIFF, WET TO SAT., SL. IRON  
STAIN, SL. ORGANICS, AQUA-GREEN TO GRAY.

CLAY, SILTY, STIFF, WET, GRAY TO  
AQUA-GREEN.

CLAY, STIFF, WET, GRAY TO AQUA-GREEN,  
FORMS SLICKENSIDES.

CLAY, SILTY, STIFF, WET, GRAY TO  
AQUA-GREEN.

CLAY, SILTY, STIFF, WET, GRAY TO  
AQUA-GREEN.

CLAY, SILTY, V. STIFF, WET, GRAY TO  
AQUA-GREEN.

## NOTES:

1. WATER LEVEL DETERMINED AFTER 40 MINUTES WITH:  
BOTTOM OF AUGER AT EL. 702.0  
BOTTOM OF HOLE AT EL. 700.4  
AFTER DRIVING SAMPLE TO EL. 697.6
2. HOLLOW STEM AUGER SET TO EL. 698.0. HOLE  
STABILIZED WITH DRILLING MUD BELOW 698.0.
3. WATER LOSS BELOW 698.0 = 1-3 GPM; 15-20 GPM  
BETWEEN 672.0 AND 687.0.
4. AN ADJACENT HOLE WAS DRILLED TO CONTINUE THE  
INITIAL HOLE FROM 677.0 TO 682.0. FROM THIS  
HOLE 2 UNDISTURBED TUBE SAMPLES WERE TAKEN  
AT EL. 695.0 AND AT EL. 685.0.
5. BOTH HOLES BACKFILLED WITH TREMIED CEMENT-  
BENTONITE GROUT.
6. SMALL PIECES OF DEFORMED IRON RECOVERED IN STD. BARREL  
BARRELL.

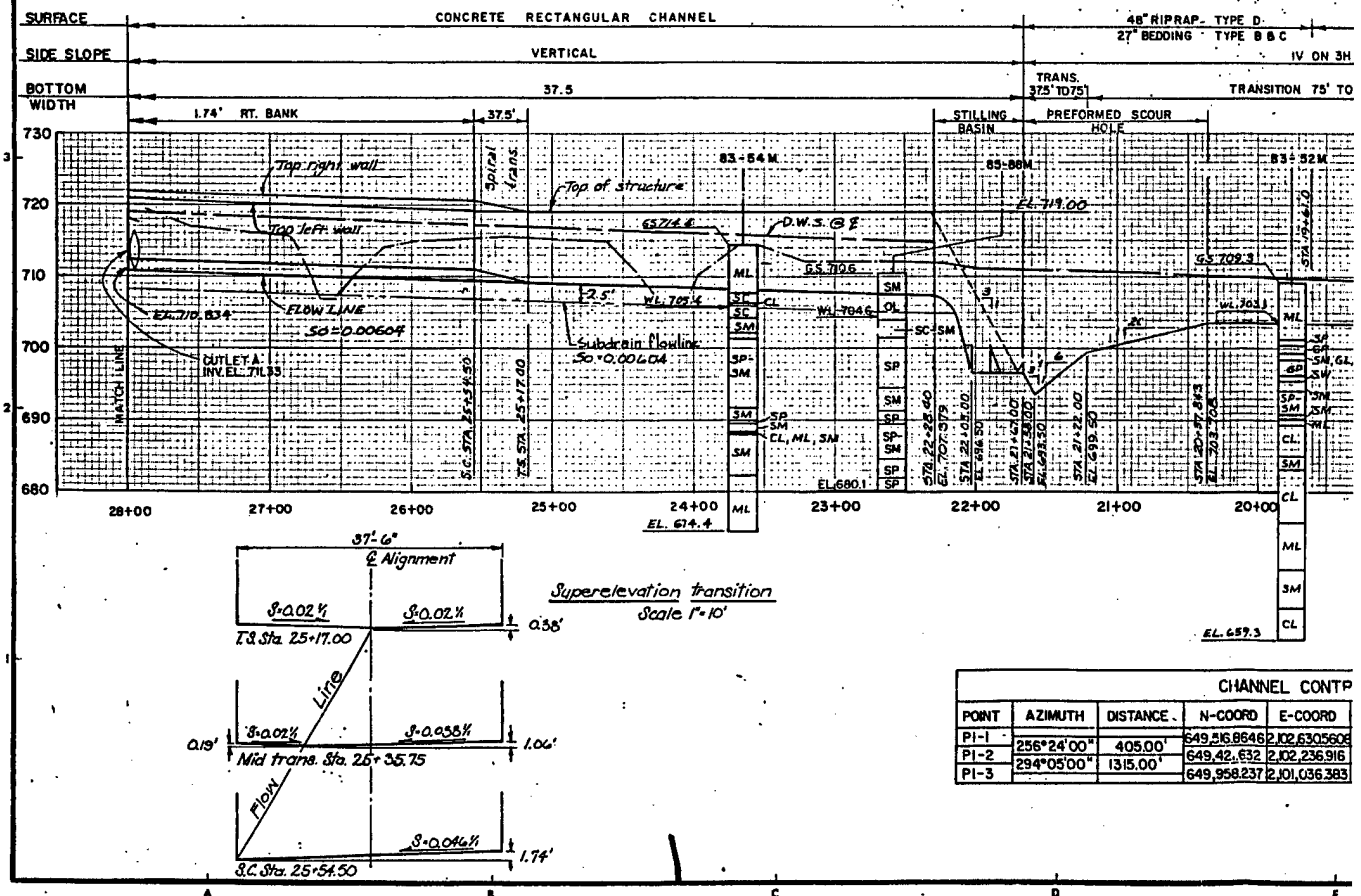
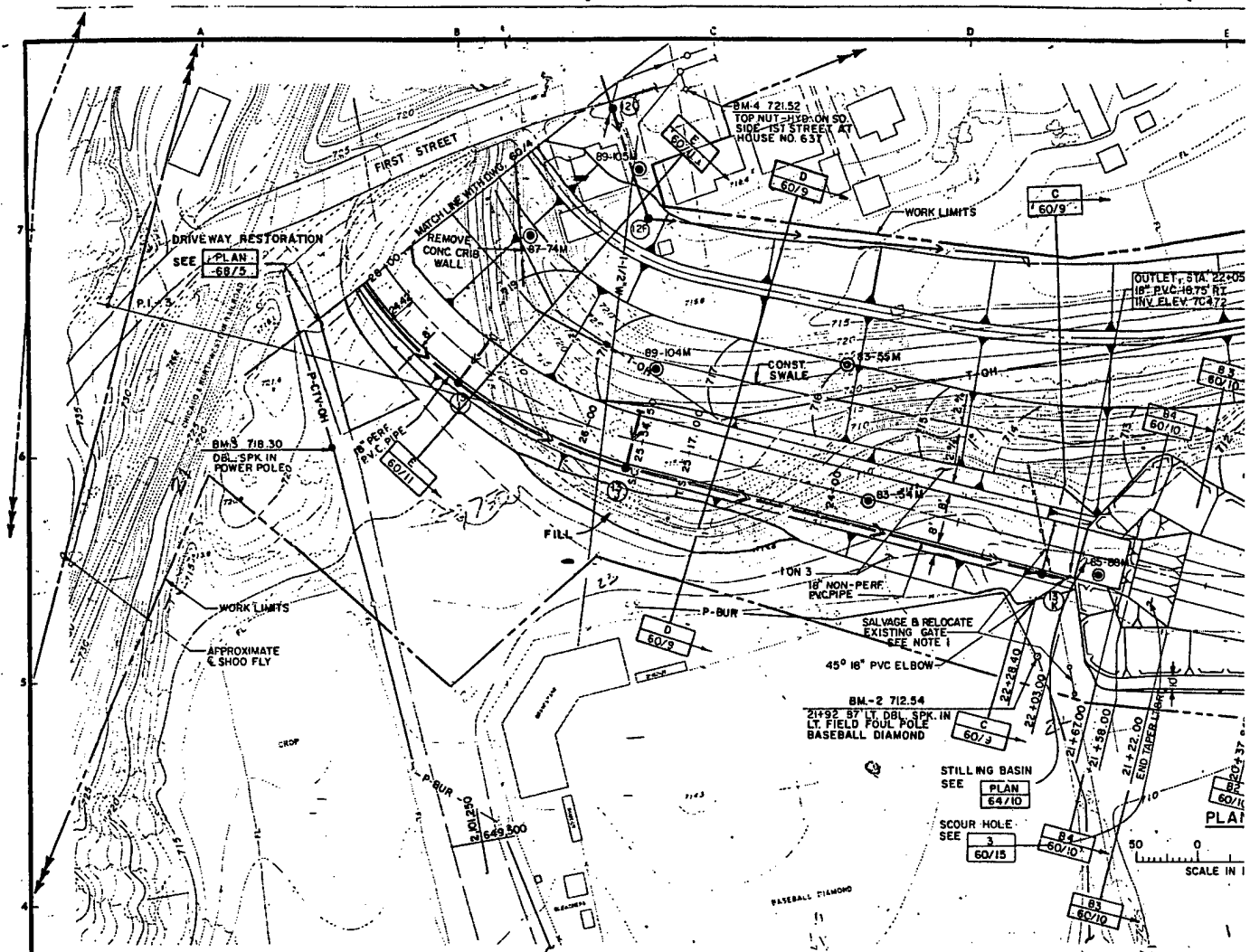
## NOTES:

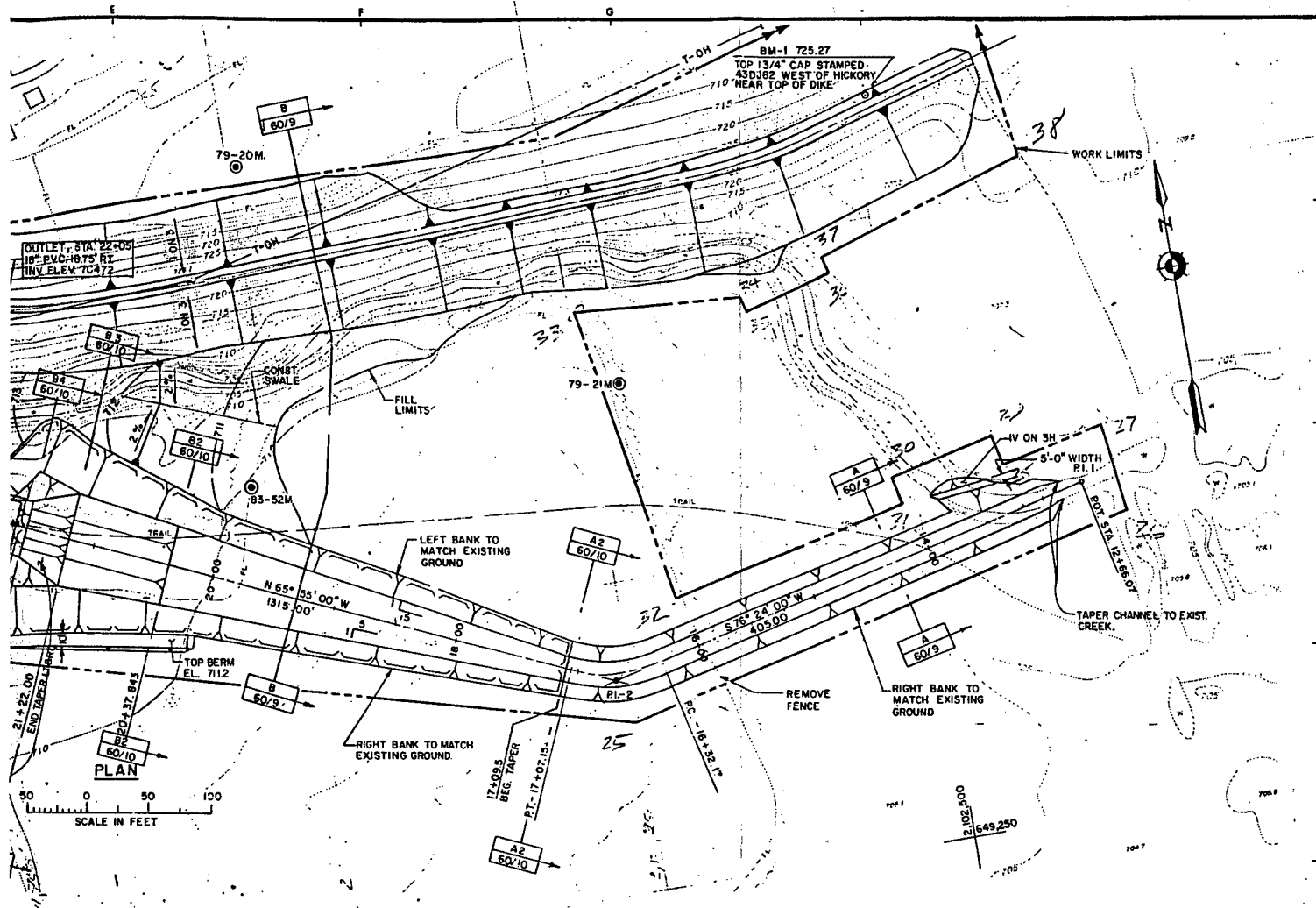
1. WATER LEVEL DETERMINED AFTER 75 MINUTES WITH:  
BOTTOM OF AUGER AT EL. 700.1  
BOTTOM OF HOLE AT EL. 699.9.  
AFTER SAMPLING TO EL. 695.1.
2. HOLLOW STEM AUGER SET TO EL. 696.1. HOLE STABILIZED  
WITH DRILLING MUD BETWEEN 696.1 AND 680.1. WATER LOSS  
BETWEEN 1 AND 2 GPM. HOLLOW STEM AUGER RESET TO EL.  
686.1. HOLE STABILIZED WITH DRILLING MUD BELOW 686.1.  
WATER LOSS 1-2 GPM.
3. 5-6 INCH UNDISTURBED SAMPLES TAKEN FROM AN ADJACENT  
HOLE.
4. BACKFILLED BOTH HOLES WITH TREMIED CEMENT - BENTONITE  
GROUT.

SYMBOL		DESCRIPTION		DATE	APPROVAL
<p align="center"><b>DEPARTMENT OF THE ARMY</b> ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>					
AE APPROVING OFFICIAL:		<p align="center">DESIGN MEMORANDUM NO. 2 <b>CHASKA STAGE 4</b> FLOOD CONTROL - MINNESOTA RIVER CHASKA CREEK STAGE 4 CHASKA, MINNESOTA BORING LOGS BORING LOGS 89-124M THRU 89-126M &amp; 89-130M</p>			
DESIGNED:	CHECKED:	DRAWN:		DATE:	
DESIGNED: JRC/PAW	CHECKED: JRC/DWM	DRAWN: GRS		DATE: 05-04-91	
CAD FILE NAME: CHASKA12.DGN		SPEC NO: DACW37-90-B-0000		DRAWING NUMBER: SHT 14 OF 14	
PLATE C-14					

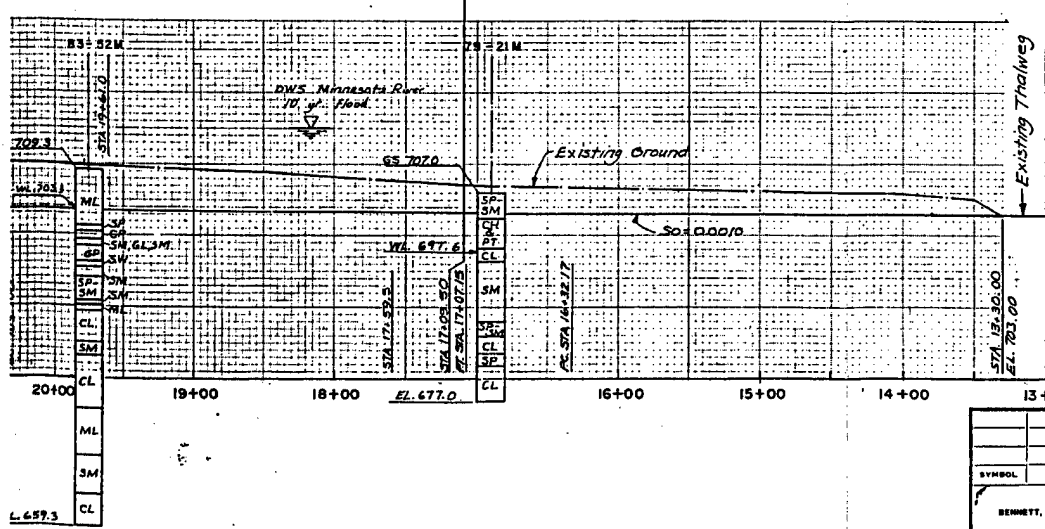








TYPE D	24" RIPRAP	TYPE C	TYPE A	500	SURFACE
TYPE B & C	21" BEDDING	TYPE B & C	9" BEDDING	IV ON 3H	SIDE SLOPE
IV ON 3H				20'	BOTTOM WIDTH
TRANSITION 75' TO 20'					

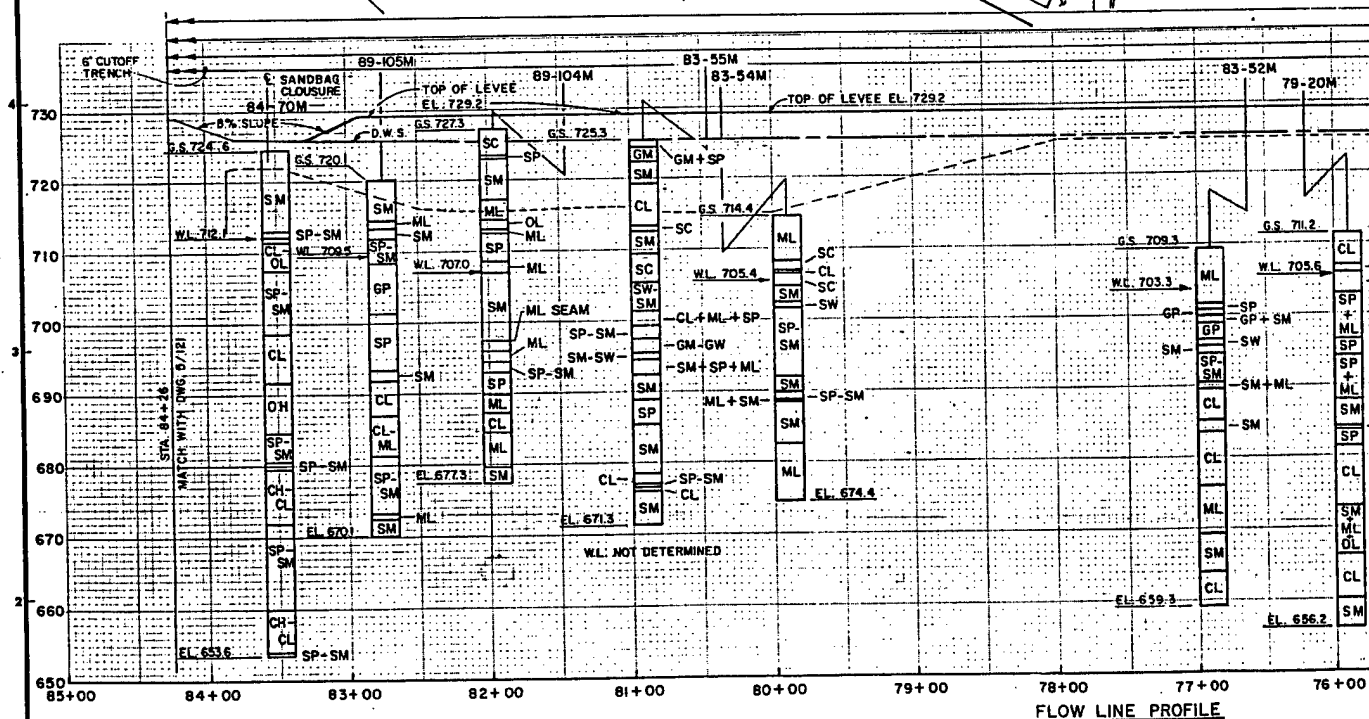
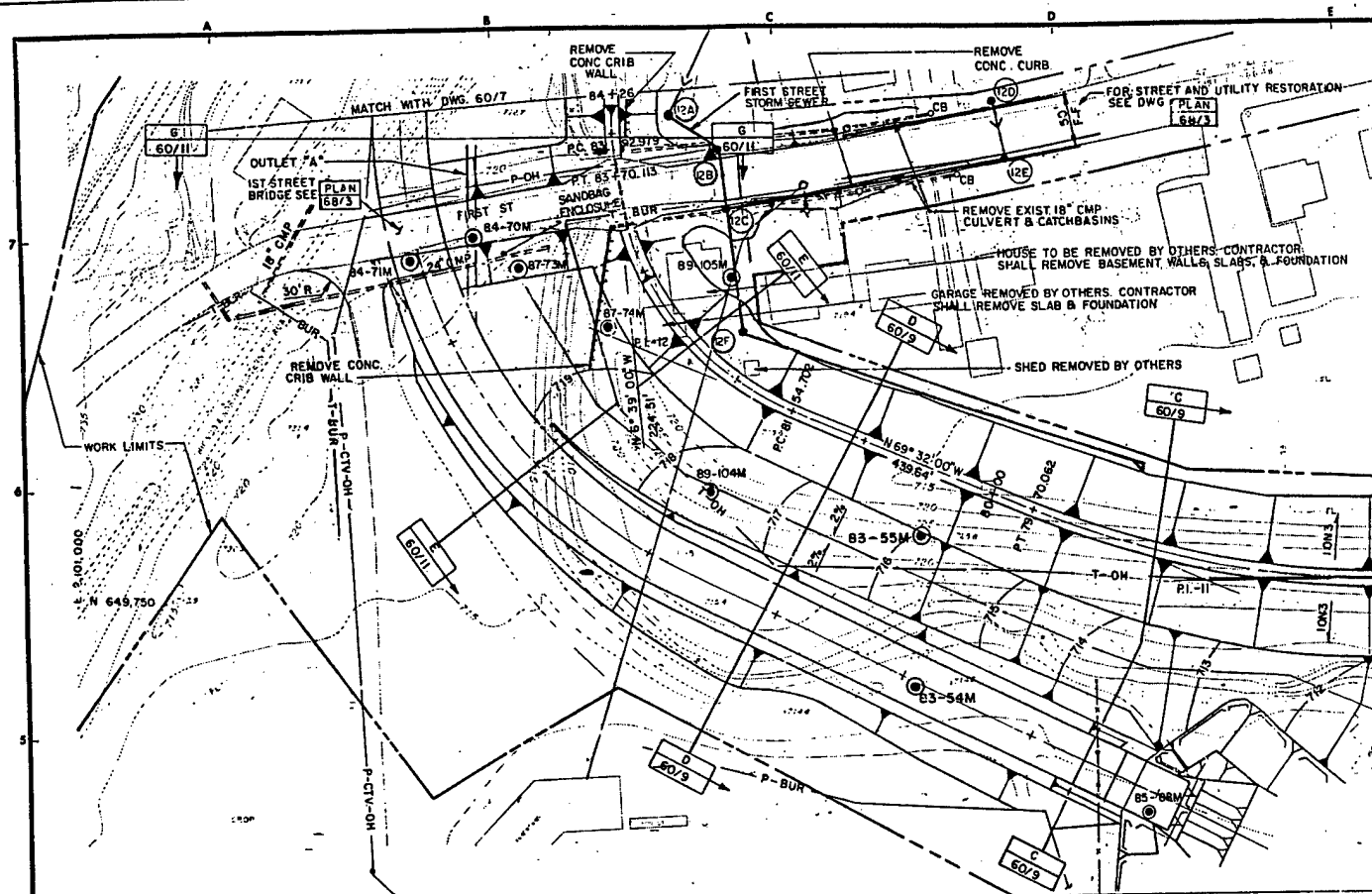


- Notes:
- Gate is to be removed and the Fish and Wildlife Service are to be notified as when they can come and get it.
- References:
- For boring legend, Dwg. M34-CH-P-10/14
  - For detailed boring logs, Dwg. M34-CH-P-10/4 thru 10/13
  - For sheet pile placement, Dwg. M34-CH-P-64/119
  - For drainage profiles, Dwg. M34-CH-P-60/117
  - For drainage structure location and pipe size Dwg. M34-CH-P-64/117
  - For levee control alignment, Dwg. M34-CH-P-60/6
  - For subdrain & manhole details, Dwg. M34-CH-P-64/119
  - For allowed depth of cut below "in-service" RR Tracks Dwg. M34-CH-P-66/11.

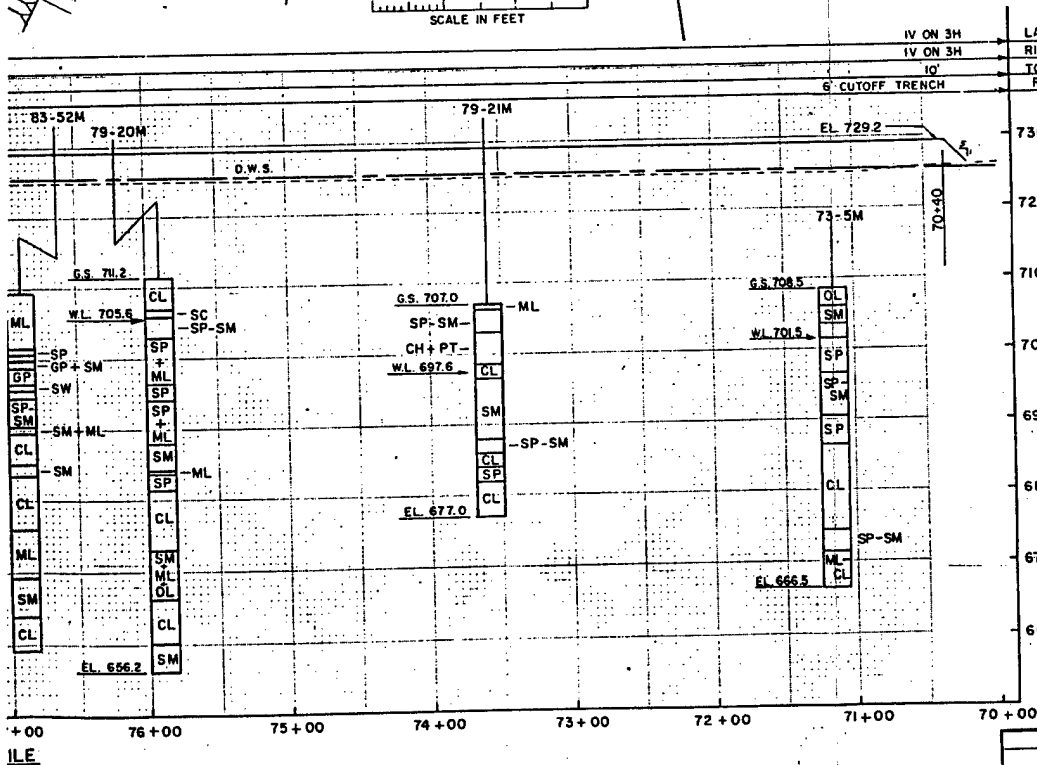
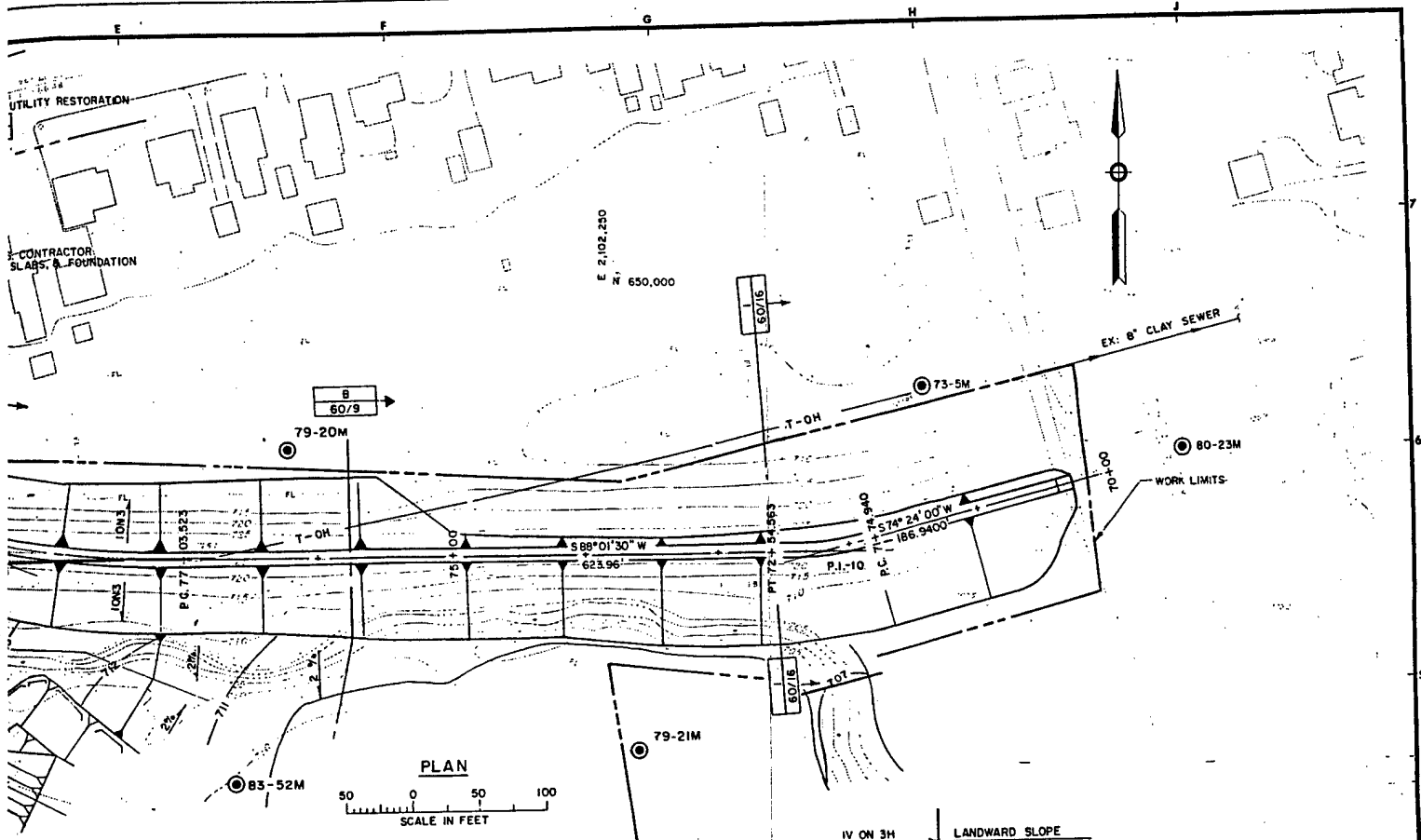
COORD	E-COORD	STATION	Δ	l <sub>s</sub>	Δ <sub>c</sub>	T	R	L	T <sub>h</sub>	CL
215.8646	2102.630560	12+66.07	-			38.90	114.00	74.98		
42.632	2102.236916	18+71.07	37°41'00"							
958.237	2101.036383	29+83.25	97°50'00"	3750	97°44'11"	402.00	390.00	62443	466.25	69943



SYMBOL		DESCRIPTION		DATE	APPROVAL
NEW		BENNETT, RINGROSE, WOLFE, JARVIS, GARDNER, INC. MINNEAPOLIS, MINNESOTA		DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA	
DESIGNED BY: T.J.S.		FLOOD CONTROL		MINNESOTA RIVER	
DRAWN BY: H.S.		CHASKA, MINNESOTA			
CHECKED BY: G.T.E.		CHASKA CREEK STAGE 2			
SUBMITTED BY:		MAIN CHANNEL PLAN & PROFILE			
CHIEF ENGR		APPROVED:		DATE: MAY 1989	
CHIEF ENGR DIVISION		CHIEF ENGR DIVISION		SCALE: AS SHOWN	
CHIEF ENGR DIVISION		CHIEF ENGR DIVISION		DRAWING NUMBER: M34-CH-P-60/5	
CHIEF ENGR DIVISION		CHIEF ENGR DIVISION		SHEET 15 OF 92	



LEVEE CON				
POINT	AZIMUTH	DISTANCE	N-COORD.	E-COORD.
P.I.-10			649,810.860	2,102,418.691
P.I.-11	268°01'30"	623.96'	649,789.356	2,101,795.102
P.I.-12	290°28'00"	439.64'	649,943.082	2,101,383.214
P.I.-13				84



- Notes:
1. Exist. conc. curb on First St. to be removed.
  2. Inspection trench this reach.
  3. Exist. sewer and water services to house being removed are to be abandoned in an approved manner.
  4. Construct 8' conc. driveway aprons on First St. to match existing driveways.

- References:
1. For boring legend, Dwg. M34-CH-P-10/4
  2. For detailed boring logs, Dwg. M34-CH-P-10/5 thru 10/8
  3. For sheet pile placement, Dwg. M34-CH-P-6/11/9
  4. For drainage profiles, Dwg. M34-CH-P-6/11/1
  5. For drainage structure location and pipe size, Dwg. M34-CH-P-6/11/7
  6. For First St. typical section, Dwg. M34-CH-P-6/11/3
  7. For Cutoff and Inspection trench Chart, Dwg. M34-CH-P-6/11/2
  8. For First Street Storm Sewer Profile, M34-CH-P-6/11/1
  9. For Street Restoration, Dwg. M34-CH-P-6/11/3
  10. For allowed depth of cut below "in-service" RR Tracks, Dwg. M34-CH-P-6/11/1

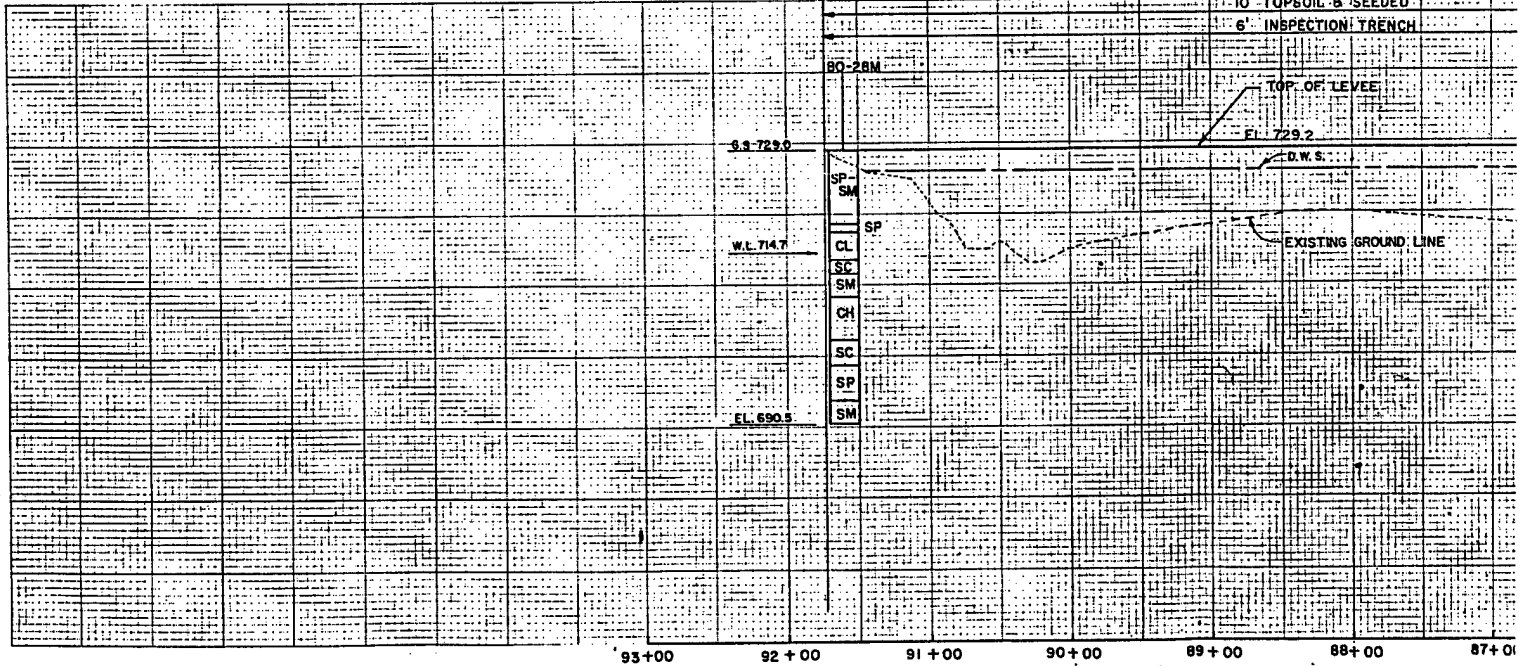
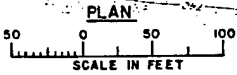
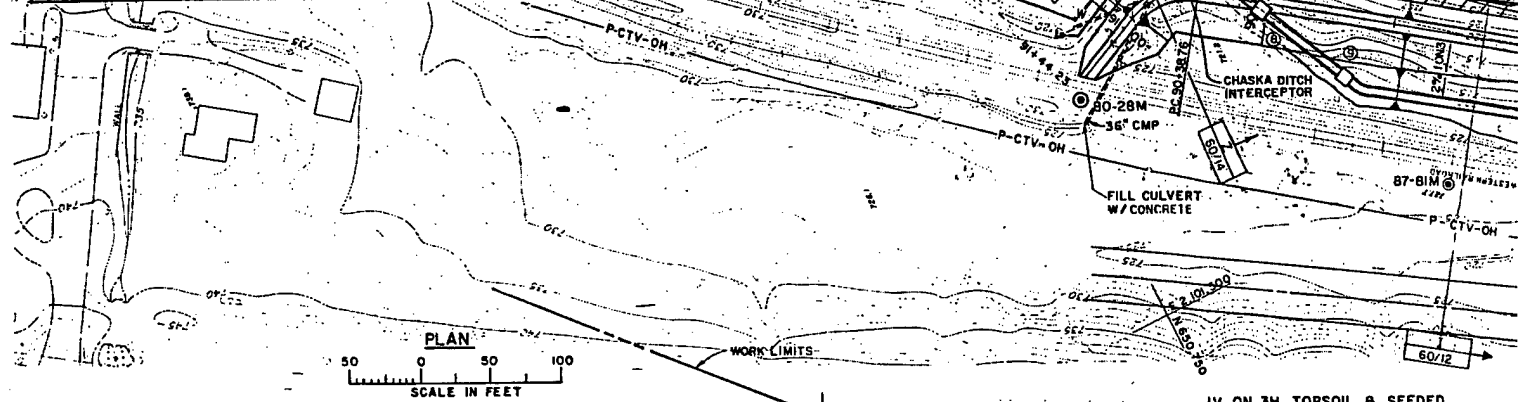
LEVEE CONTROL LINE TRAVERSE									
N-COORD	E-COORD	STATION	Δ	Δc	T	R	L	Ts	CL
49,810.86	2,102,418.69	72+14.940	13°37'30"	—	4000'	334,830	79,623	—	—
49,789,356	2,101,795.102	78+38.523	22°26'30"	—	13500'	680,500	266,539	—	—
49,943.08	2,101,383.214	82+74.702	62°53'00"	—	12000'	196,270	215,411	—	—
		84+74.623	42°05'15"	—	81.64'	212,207	115,880	—	—

SYMBOL		DESCRIPTION	DATE	APPROVAL
BENNETT, HARGROVE, WOLFE, JARVIS, GARDNER, INC.		MINNEAPOLIS, MINNESOTA		
DESIGNED BY: T.J.S.		FLOOD CONTROL MINNESOTA RIVER		
DRAWN BY: H.S.		CHASKA, MINNESOTA		
CHECKED BY: C.T.E.		CHASKA CREEK STAGE 2		
SUBMITTED BY:		LEVEE PLAN & PROFILE		
SHEET 16 OF 92		STA. 70+28 TO 84+26		
APPROVED:		DATE: MAY 1989		
CHIEF: ED - CH		CHIEF: ENR DIVISION		
SCALE: AS SHOWN		DRAWING NUMBER: M34-CH-P-60/6		
		SHEET 16 OF 92		



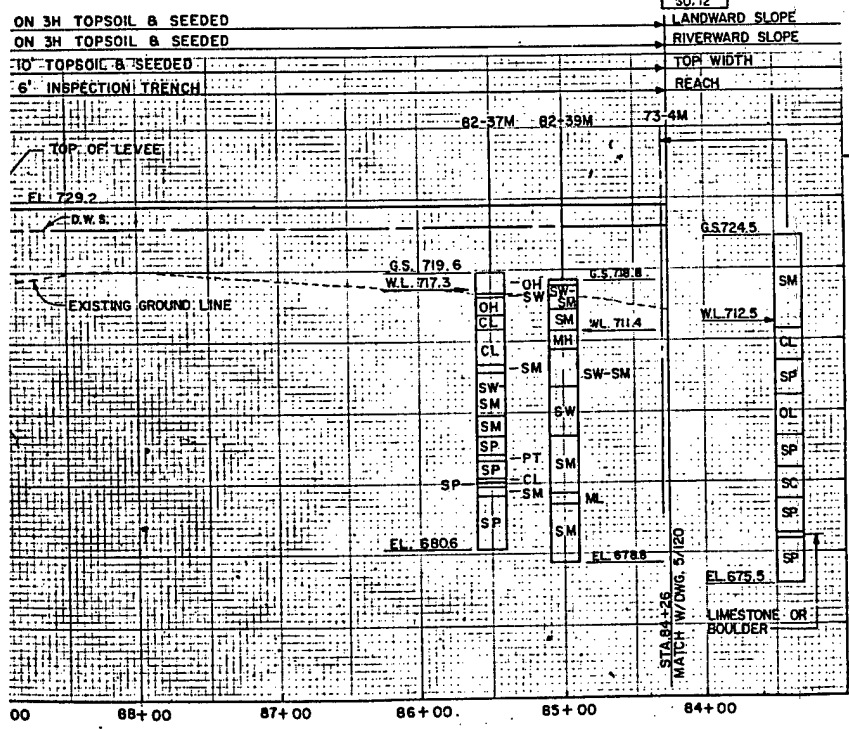
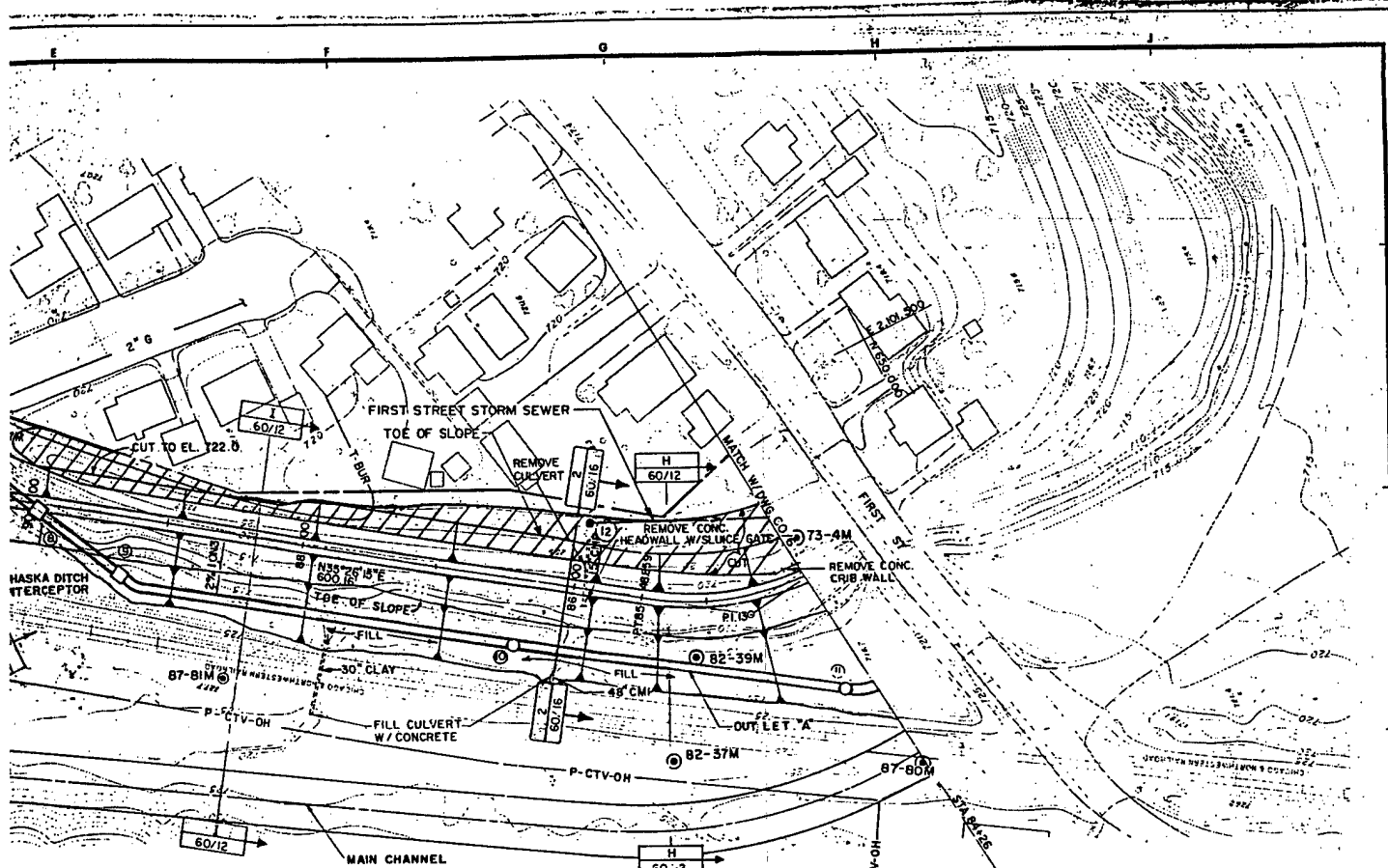
# CUTOFF AND INSPECTION TRENCH

Levee Station	Trench Type	Cutoff From Levee Centerline	Depth of Trench (Below stripping line)	Bottom of Trench Elevation
70+50-72+00	X	45 feet riverward	-	701.0
72+00-74+30	X	45 feet riverward	-	700.0
74+30-75+40	X	45 feet riverward	-	707.0
75+40-79+85	X	45 feet riverward	-	707.0
79+85-84+00	X	transition to 30' levee on PCTV-OH	-	709.0
84+00-84+24	X	30' levee on PCTV-OH	-	709.0
84+24-End of Levee	X	30' levee on PCTV-OH	6 feet	varies
Channel Sta. 64+55-66+55	X	30' levee on PCTV-OH	6 feet	varies



LEVEE CONTROL LINE TRAV							
POINT	AZIMUTH	DISTANCE	N-COORD.	E-COORD.	PI STATION	Δ	ℓ
PI-13	35°26'15"	600.16'	650,166.082	2,101,357.215	84+74.623	42°05'15"	
PI-14	335°52'30"	82.10'	650,655.061	2,101,705.197	90+67.375	59°33'45"	
END			650,729.990	2,101,671.640			





Notes:  
 1. Inspection trench required this reach.

References:  
 1. For outlet "A" plan and profile, Dwg. M34-CH-P-60/8.  
 2. For First street storm sewer profile, Dwg. M34-CH-P-60/17.  
 3. For concrete apron and trash guard details, Dwg. M34-CH-P-64/21.  
 4. For allowed depth of cut below "in-service" R.R. Tracks, Dwg. M34-CH-P-66/11.

LEVEE CONTROL LINE TRAVERSE									
E-COORD.	Pt. STATION	Δ	Δs	T	R	L	Tc	CL	
22,101,357.215	84+74.623	42°05'15"		81.644'	212.2066'	155.880'	—		
812,101,705.197	90+67.375	59°33'45"		28.614'	50.00'	51.978'	—		
12,101,671.640									

SYMBOL		DESCRIPTION		DATE	APPROVAL
BENNETT, BROWNE, WOLFELD, JARVIS, GARDNER, INC. MINNEAPOLIS, MINNESOTA		DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA			
DESIGNED BY: T.J.S.	FLOOD CONTROL		MINNESOTA RIVER		
DRAWN BY: T.J.S.	CHASKA, MINNESOTA				
CHECKED BY: G.J.E.	CHASKA CREEK STAGE 2				
SUBMITTED BY:	LEVEE PLAN & PROFILE				
	STA. 84+26 TO 91+73				
APPROVED:	DATE:		MAY 1989		
CHEF, E.A.-CH	BRANCH	CHIEF CIVIL DIVISION	AS SHOWN (DACW37-89-B-0020)		
		DRAWING NUMBER		M34-CH-P-60/71	
		SHEET		17 OF 92	

2

760  
750  
740  
730  
720  
710  
700  
690  
680  
670  
660

**73-4M**  
8 MARCH 1973

Blows/Foot	M.C.	LL	PL
STD. G.S. 724.5			
11	10.7	SM	Fine, brown (fill)
26	14.3		
2	W.L. 712.5	CL	Sandy, silty, black
15			Sandy, silty, brown, gray
3		SP	Medium, some gravel, gray
35			
17		OL	Silty, black
4			
5		SP	Medium, some gravel, organic lenses, gray
12			
6		SC	Organic lenses, dark gray - brown
2			
1		SP	Medium, some gravel, gray
17			Limestone or boulder
12			
30			Fine, light brown
100/0.4			
55	EL 675.5		

**73-5M**  
8 MARCH 1973

Blows/Foot	M.C.	LL	PL
STD. G.S. 708.5			
7		OL	Silty, clayey, black
12		SM	Fine, brown
5	W.L. 701.5	SP	Fine, brown $D_{10} = 0.12$
8			
23		SP-SM	Medium, some gravel, brown $D_{10} = 0.11$
27			
26		SP	Fine silt lenses, brown
42			Laminated, silty, sandy, gray
16		CL	Gray
22			
9			
19			
72		SP-SM	Fine, light, gray
53			
25		ML-CL	Brown - gray
36	EL 666.5		

**79-20M**  
14-15 MAY 1979

Blows/Foot	M.C.	LL	PL
2 x 2 1/2" STD. G.S. 711.2			
3	21.3	CL	36 19 Sandy, silty, black
	W.L. 705.6		
	17.0	SP-SM	SC, light brown
			Light brown $D_{10} = 0.080$
60	8	SP	Fine sand & silt interbedded light brown
		SM	
		ML	
35		SP	Fine brown
83		SP	Light brown & gray
		ML	Fine & silt interbedded
64	17.4		
74		SM	Fine brown
20	20	SP	Medium, some gravel, gray
			Fine to medium, light brown
23			
20.7		CL	37 18 Gray Laminated
26			
37		SM	Sand, laminated, silt & organic, gray
80	20.1		
19		CL	43 17 Organic, laminated, gray
54	23.6		
39			
94	29	SM	Fine, light gray
	EL 656.2		Medium

**80-23M**  
5 AUGUST 1980

Blows/Foot	M.C.	LL	PL
2 x 2 1/2" STD. G.S. 725.7			
50		SP	Gravelly, dark brown
		ML	Sandy, brown
24	14.8	SC	35 14 Fine to coarse, gravelly, dark brown
44			
17	16.4	SC	Fine to coarse, gravelly, dark brown
	3.5		
18		SP	Fine to coarse, brown
15	17.2		
29		SC	38 13 Fine to medium, gravelly, brown-black
14	26.7	CL	Brown
	16.4	SC	33 Silty, green-gray
	9.7	CL	Sandy, silty, black
	W.L. 701.5		Dark brown-black, quick concrete
			Sandy dark brown
			$D_{10} = 0.093$
9			Fine to medium, reddish brown
26		SP-SM	
5			Brown
			$D_{10} = 0.082$
42			
29		ML	Sandy, gray
35			
47		ML	Clayey, gray
		SM	Fine, gray
24			
35		ML	Clayey, gray
25			
62		SP	Fine, gray
49	EL 666.1		ML-CL, gray

**80-28M**  
8 AUGUST 1980

Blows/Foot	M.C.	LL	PL
2 x 2 1/2" STD. G.S. 729.0			
20		SP-SM	Fine to coarse, gray
17			
24	8		Fine to medium, gray
	19.1		
	41.7		
14		CL	43 21 Silty, sandy, dark gray
	30.5		41 20 Silty, dark gray
6	W.L. 714.7	SC	Fine, dark gray
		SM	Fine to coarse, dark gray
4		CH	51 18 Sandy, dark gray
	28.0		
3	23.1		
	23.9	SC	26 14 Medium, gravelly, gray
16			
27	13	SP	Fine to medium, gray
22		SM	Fine to medium, gray
	EL 690.5		

Water level is approximate

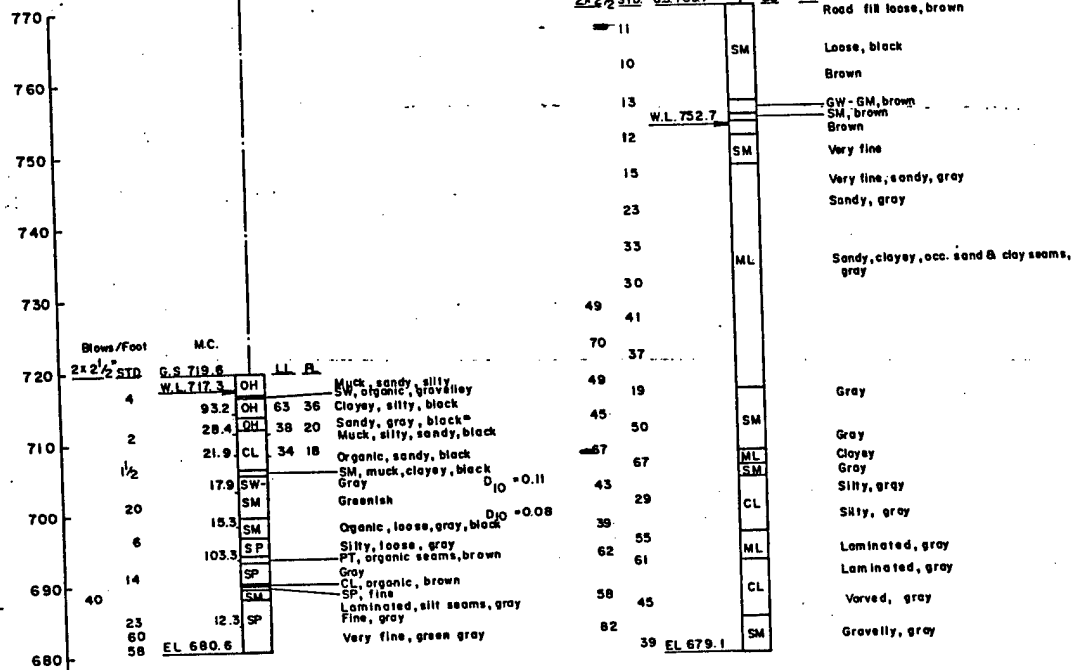
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670  
660



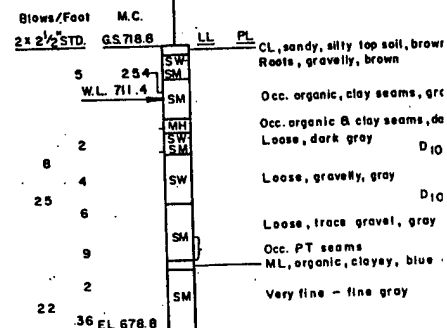
82-37M  
11 MAR. 1982

82-38M  
14 OCT. 1982

82-39M  
16 OCT. 1982



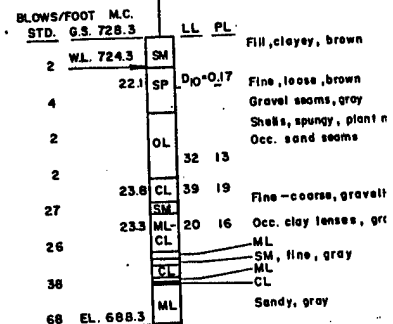
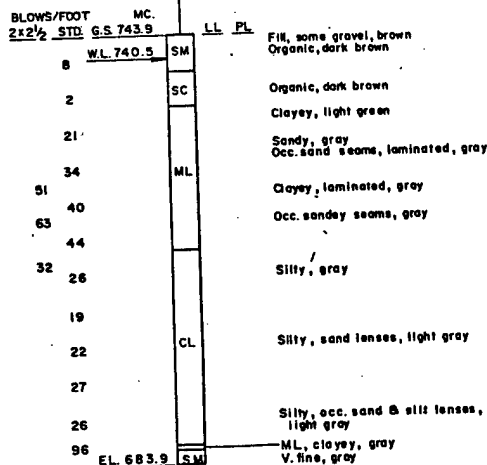
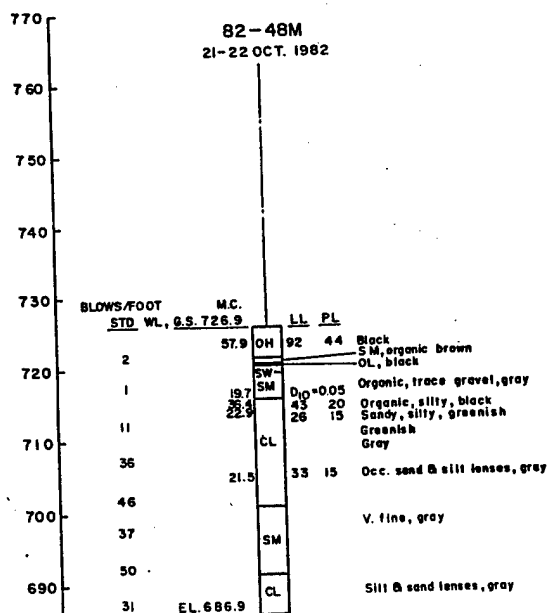
\*Classified from undisturbed sample



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21-22 OCT. 1982

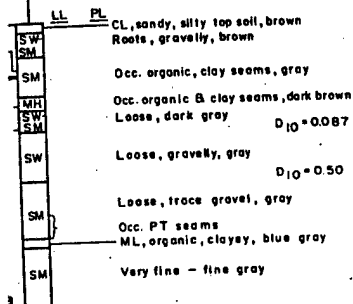
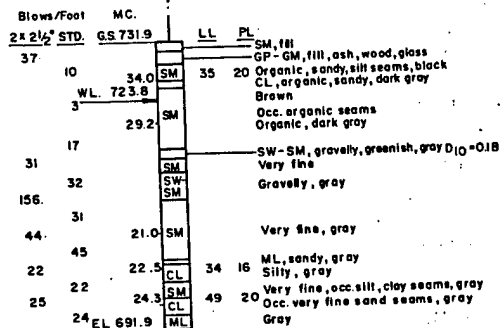
82-49M  
19 OCT. 1982

82-50M  
8 OCT. 1982

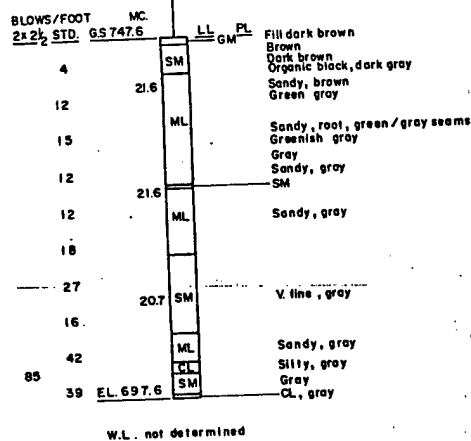


- 39M  
1982

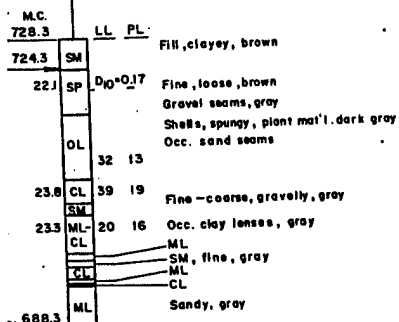
82-40M  
7 OCT. 1982



82-47M  
21 OCT. 1982



82-50M  
8 OCT. 1982

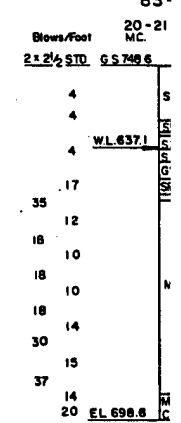
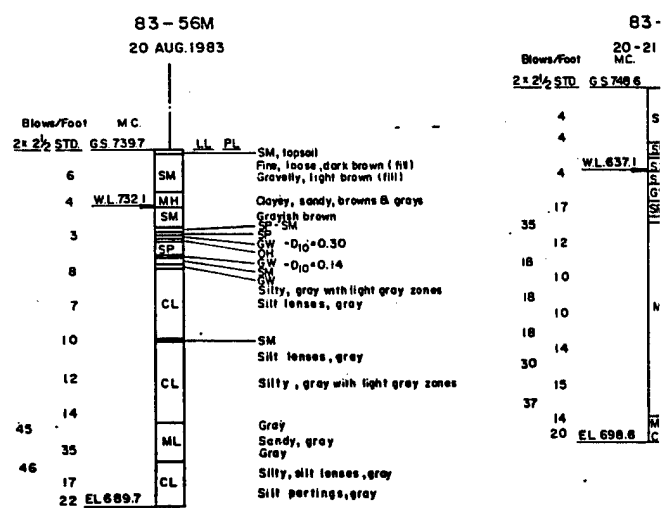
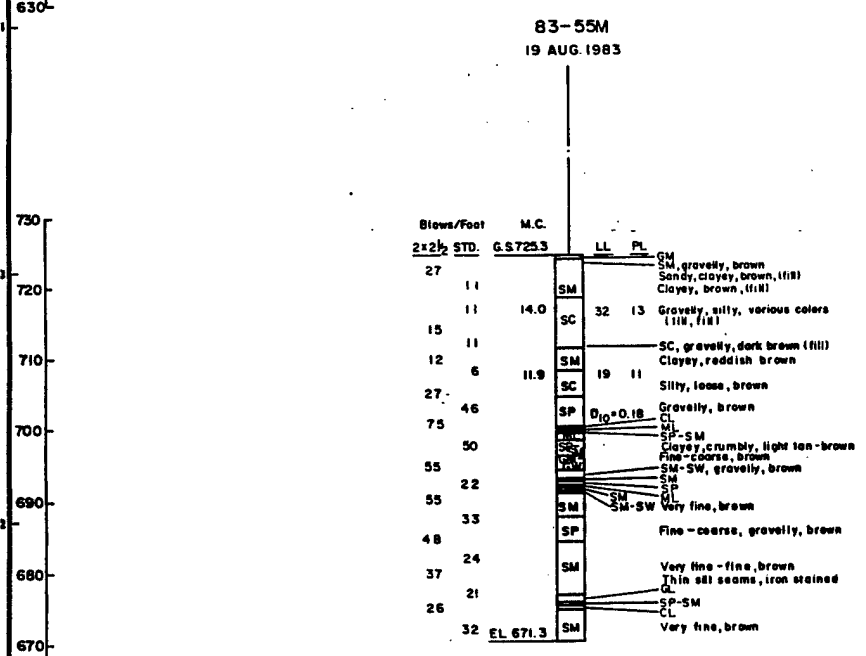
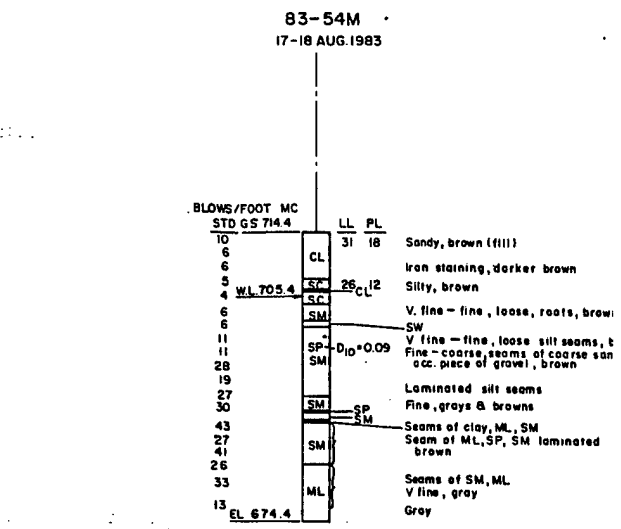
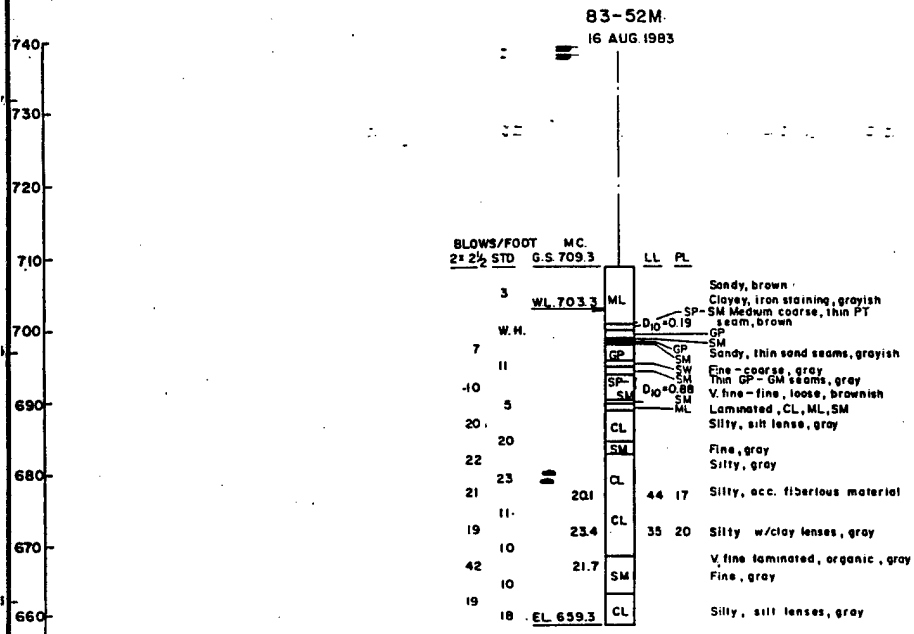


SYMBOL		DESCRIPTION		DATE	APPROVAL
<p>DEPARTMENT OF THE ARMY ST PAUL DISTRICT CORPS OF ENGINEERS ST PAUL, MINNESOTA</p>					
<p>DESIGNED BY: PDM DRAWN BY: GAO CHECKED BY: LHB SUBMITTED BY:</p>					
<p>FLOOD CONTROL CHASKA, MINNESOTA CHASKA CREEK STAGE 2 BORING LOGS 82-37M THRU 82-50M</p>					
APPROVED:				DATE: MAY 1989	
SCALE: AS SHOWN DACW37-89-B-0020				DRAWING NUMBER M34-CH-P-10/5 SHEET 5 OF 92	

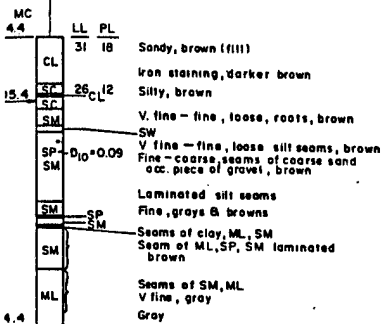


PLATE C-20

CONTRACT NO. DACW37-89-C-1004



83-54M  
17-18 AUG. 1983



83-57M

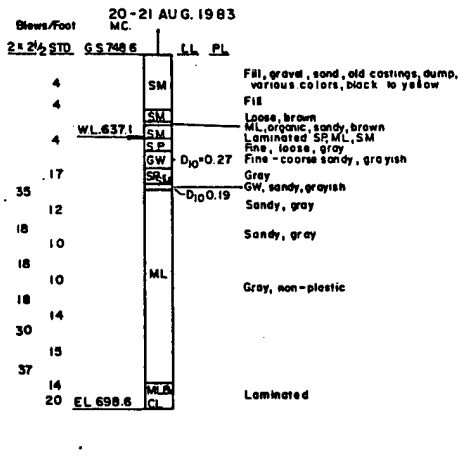


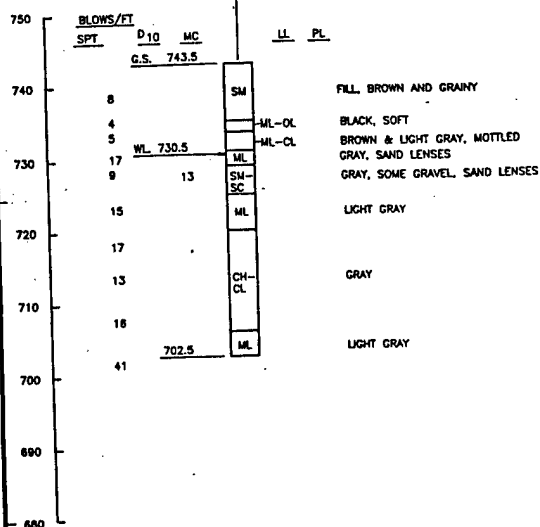
PLATE C-21

SYMBOL		DESCRIPTION		DATE		APPROVAL	
DEW BENNETT, HINGGOLD, WOLFELD, JARVIS, GARDNER, INC. MINNEAPOLIS, MINNESOTA				DEPARTMENT OF THE ARMY ST PAUL DISTRICT CORPS OF ENGINEERS ST PAUL, MINNESOTA			
DESIGNED BY: PDM		FLOOD CONTROL		MINNESOTA RIVER			
DRAWN BY: GAO		CHASKA, MINNESOTA					
CHECKED BY: LHB		CHASKA CREEK STAGE 2					
SUBMITTED BY:		BORING LOGS					
E.C.P. 10-0		APPROVED:		DATE:			
E.C.P. 10-0		E.C.P. 10-0		E.C.P. 10-0			
				AS SHOWN (DACW37-89-B-0020)			
				DRAWING NUMBER			
				M34-CH-P-10/6			
				SHEET 6 OF 92			

CONTRACT NO. DACW37-89-C-1004

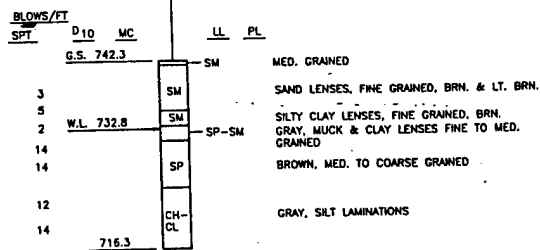
## 84-64M

03 FEB. 84



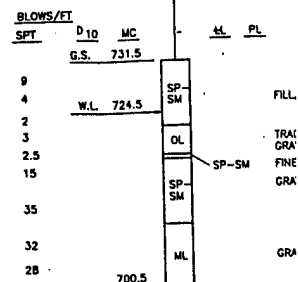
## 84-65M

03 FEB. 84



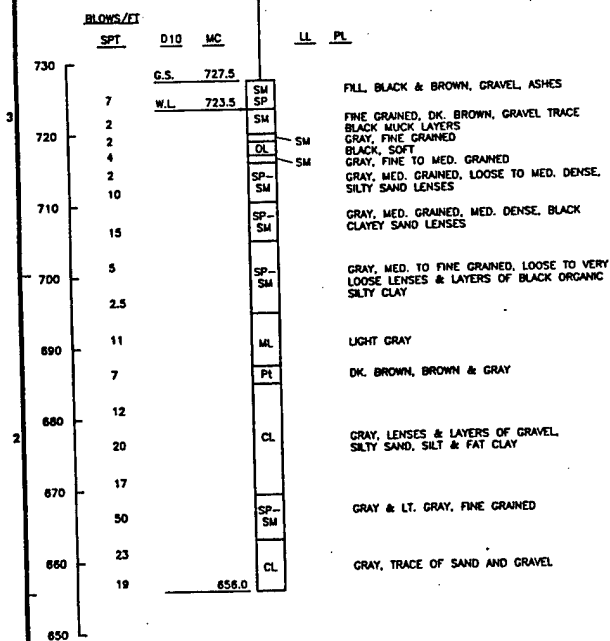
## 84-66M

03 FEB. 84



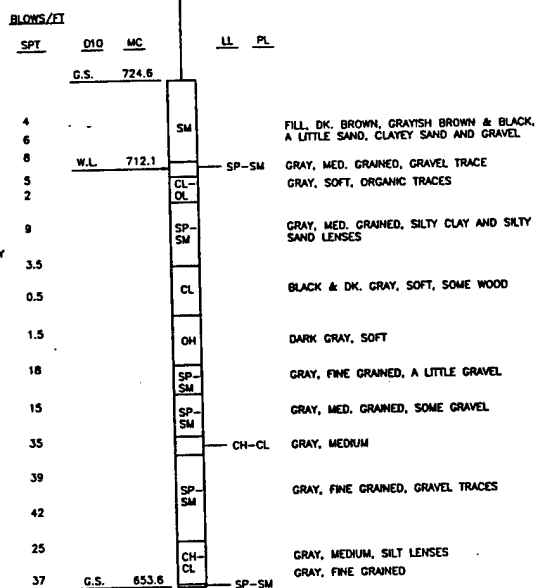
## 84-69M

24-27 FEB. 84



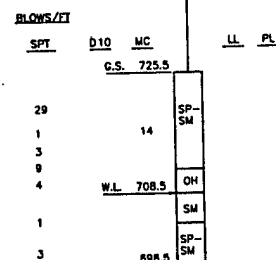
## 84-70M

02 FEB. 84



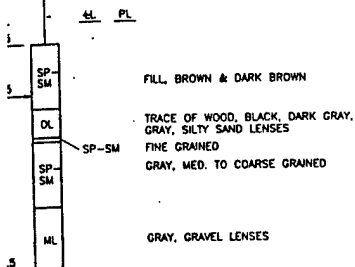
## 84-71M

01 FEB. 84

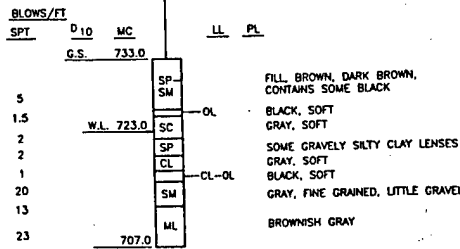




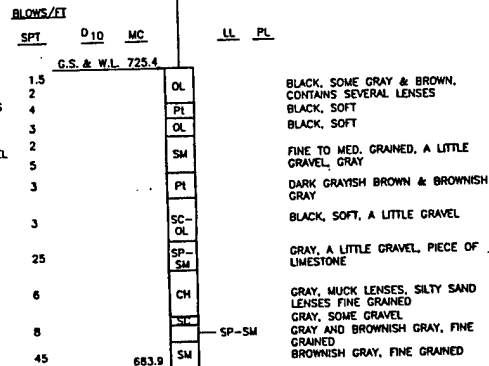
84-66M  
03 FEB. 84



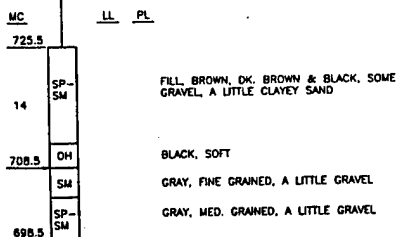
84-67M  
02 FEB. 84



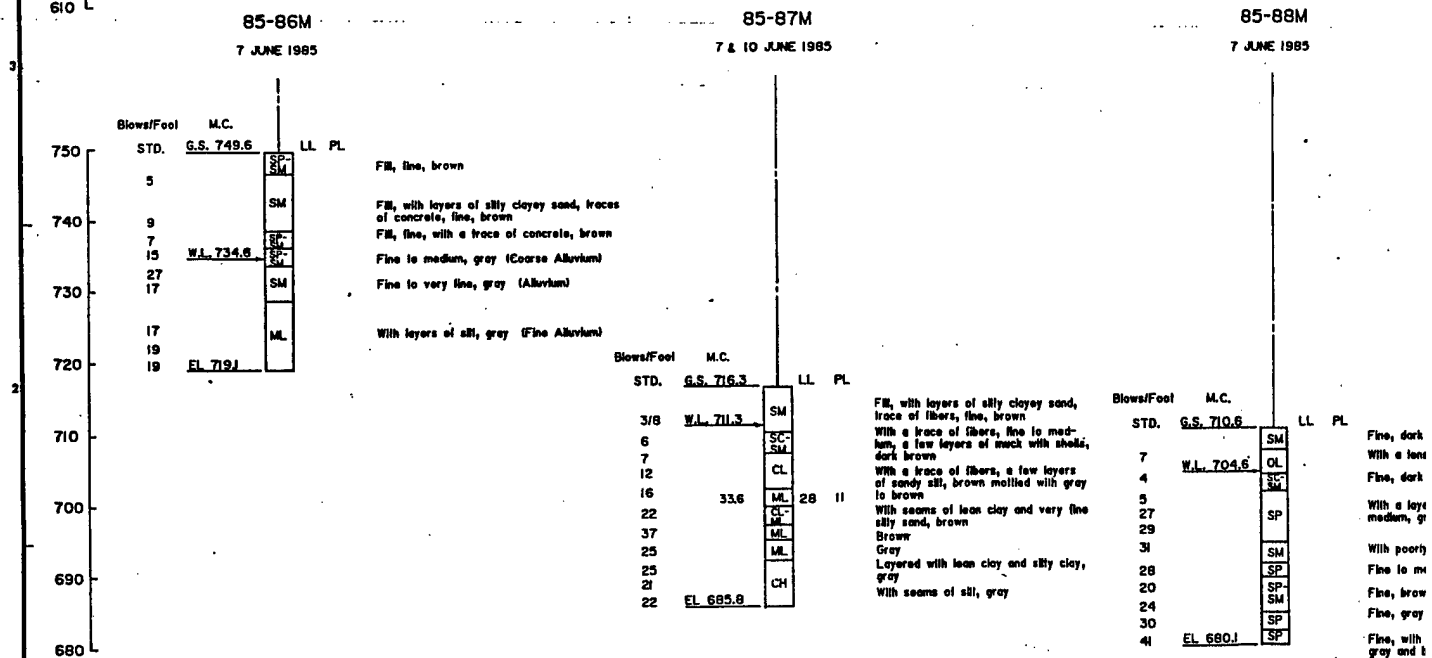
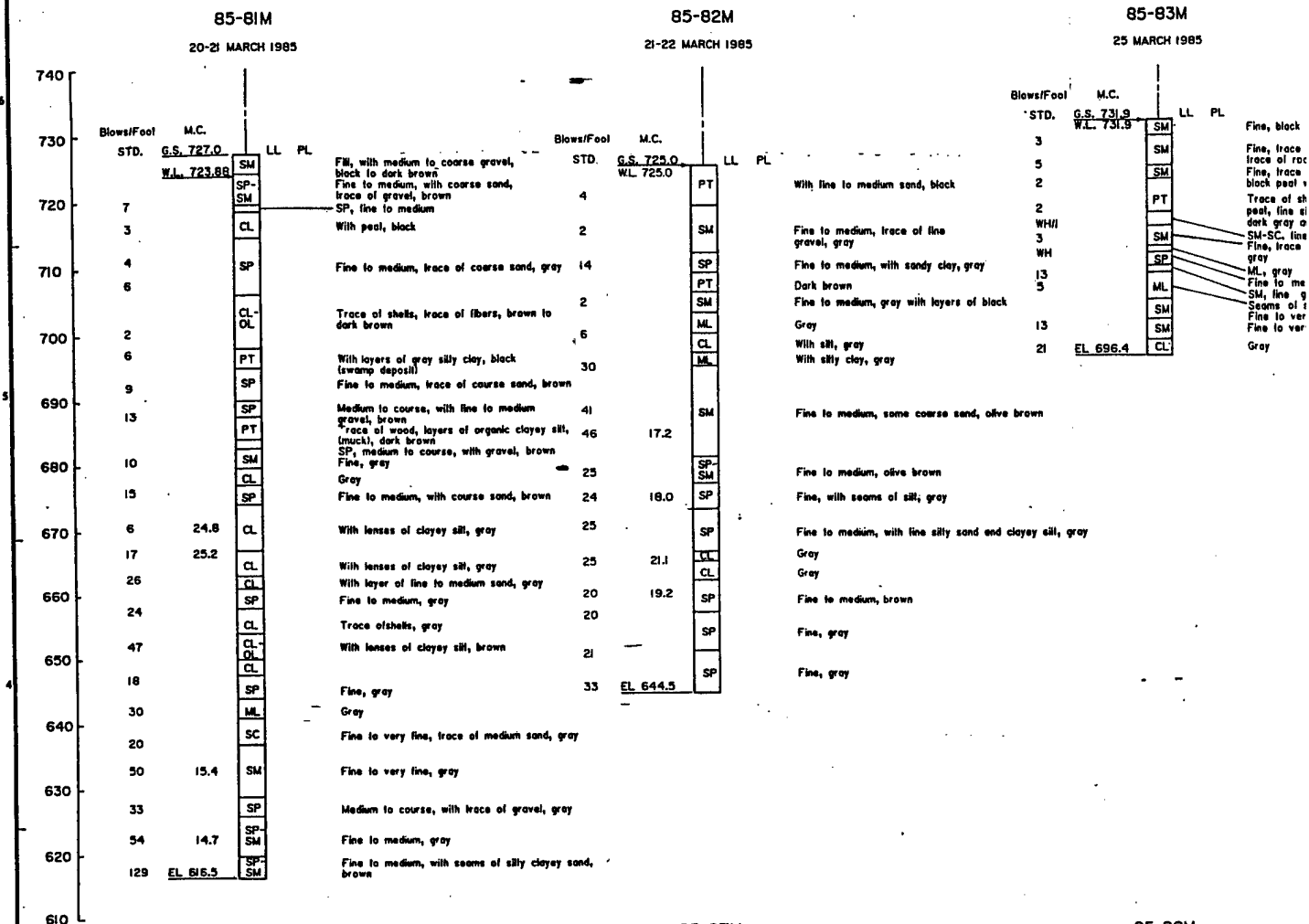
84-68M  
27 FEB. 84

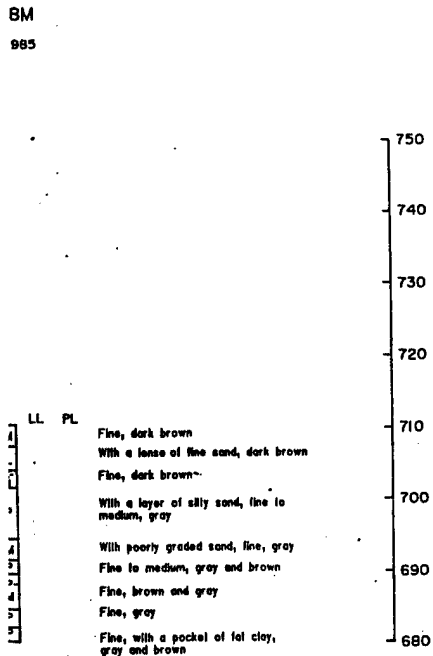
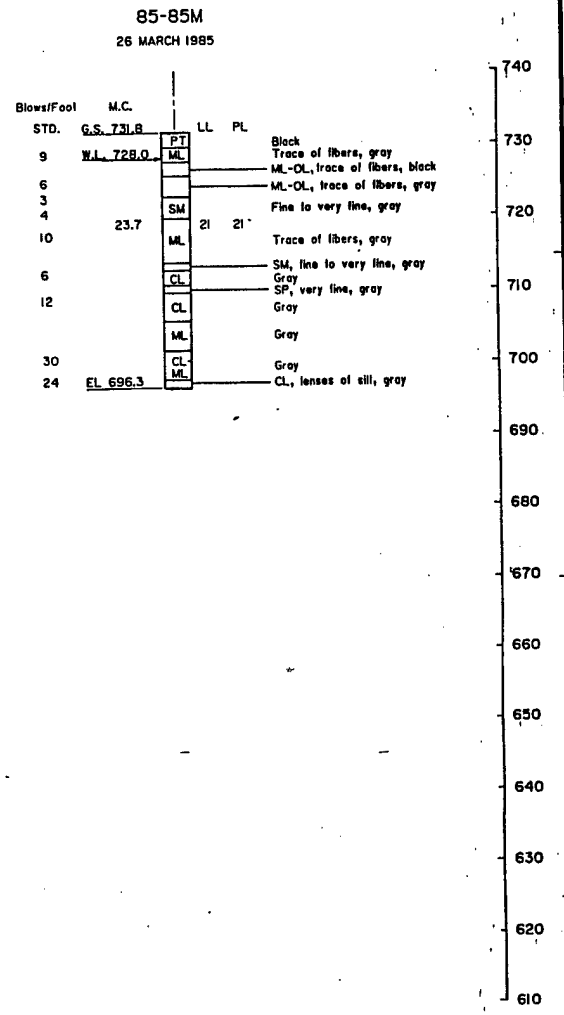
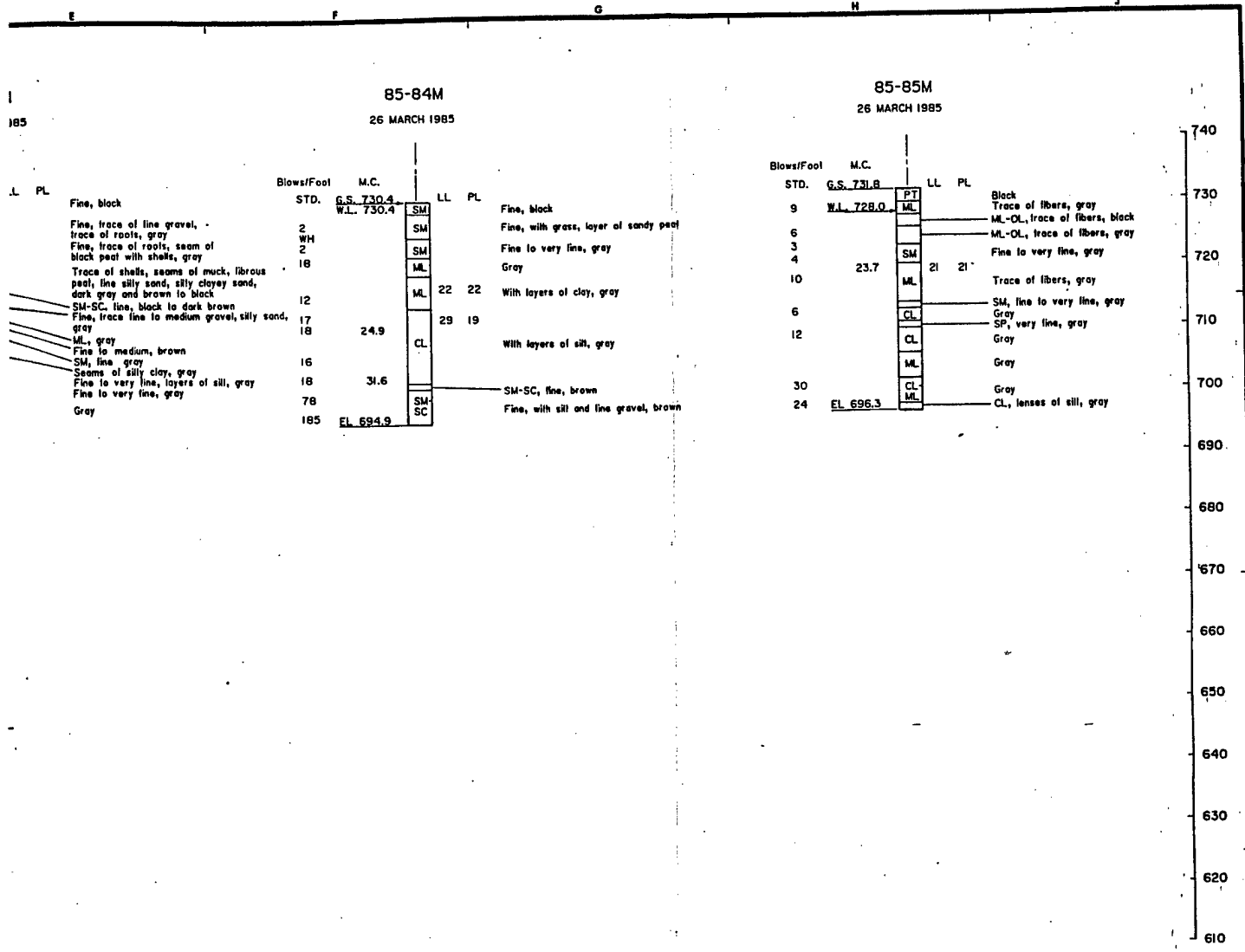


84-71M  
01 FEB. 84

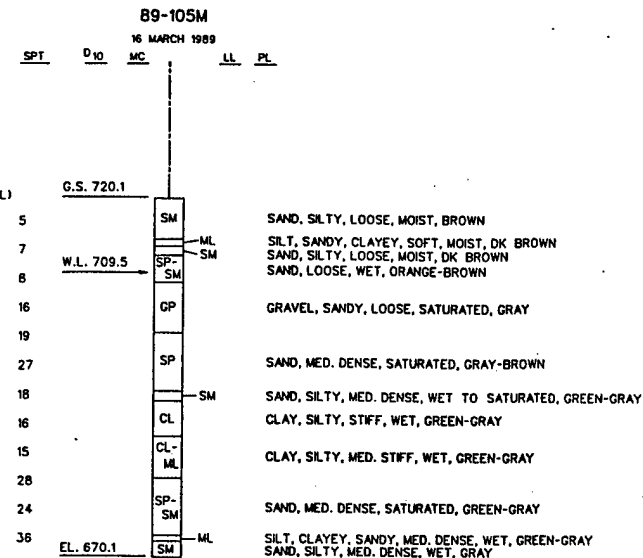
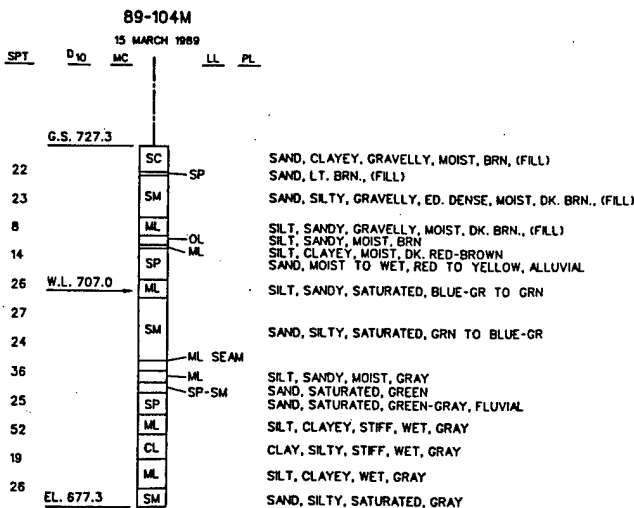
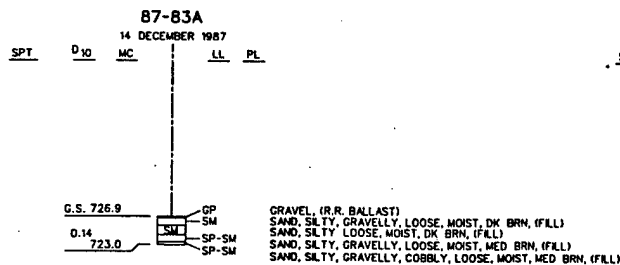
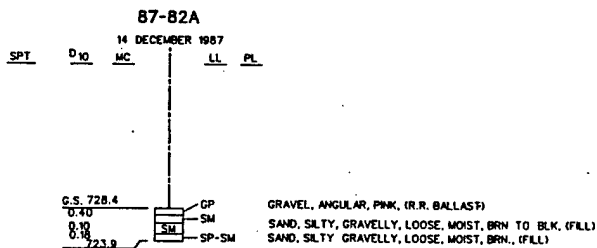
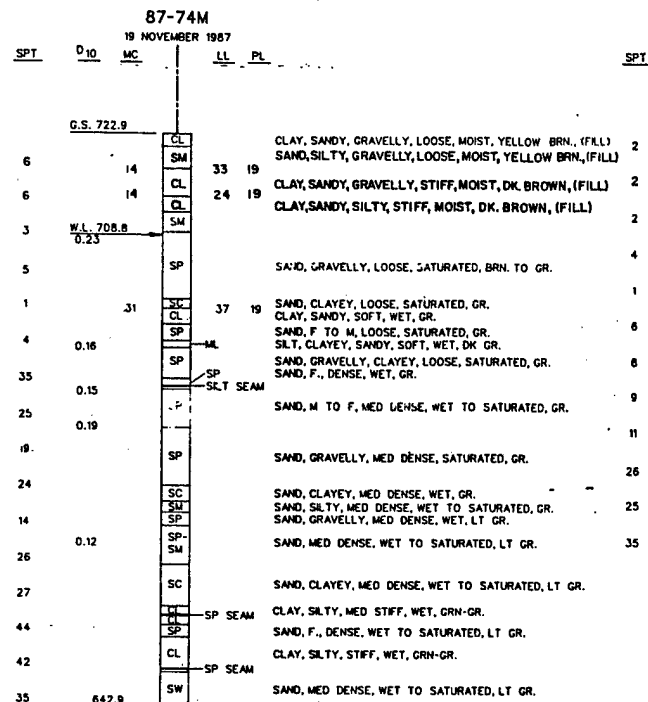
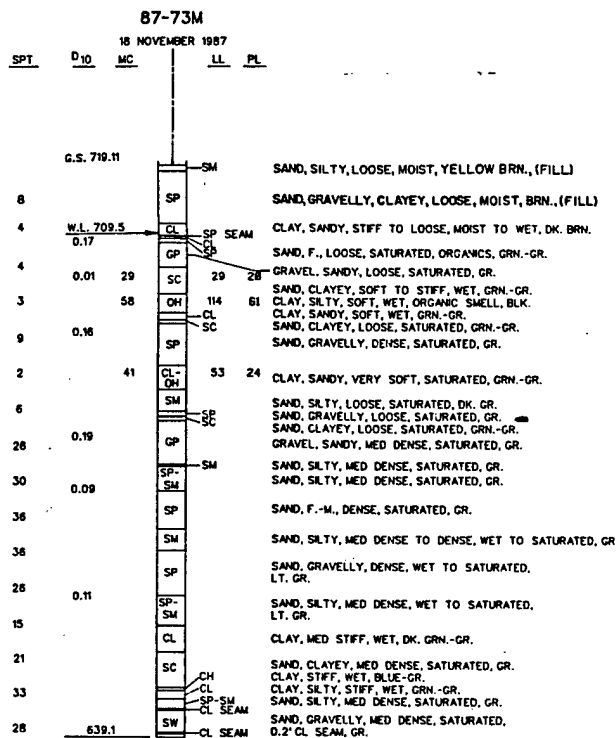


SYMBOL	DESCRIPTION	DATE	APPROVAL
<p>DESIGNED BY: J.R.C.</p> <p>DRAWN BY: G.R.S.</p> <p>CHECKED BY: P.A.W.</p> <p>SUBMITTED BY:</p>			
<p>DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA</p>			
<p>FLOOD CONTROL - MINNESOTA RIVER CHASKA, MINNESOTA CHASKA CREEK STAGE 2 BORING LOGS 84-64M THRU 84-71M</p>			
APPROVED BY:		DATE: MAY 1989	
SHEET: 7 OF 92		DRAWING NUMBER: M34-CH-P-10/7	
SHEET: 7 OF 92		SHEET: 7 OF 92	



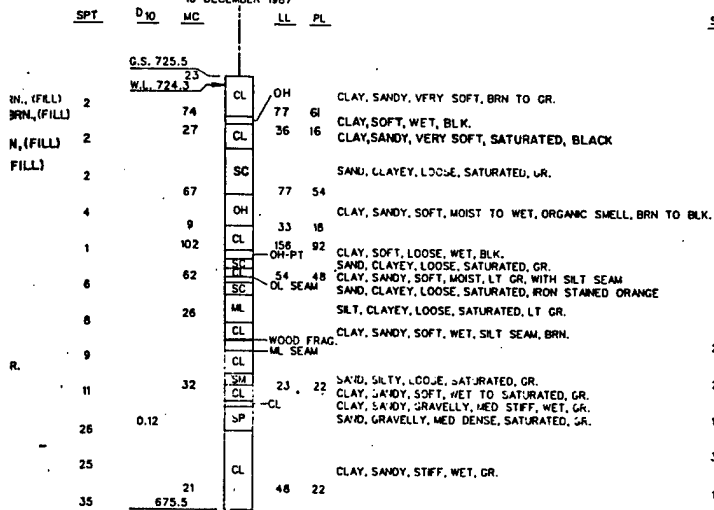


SYMBOL		DESCRIPTION		DATE		APPROVAL	
BENNETT, RIMROSE, WOLFELD, JARVIS, BARDNER, INC.		MINNEAPOLIS, MINNESOTA		DEPARTMENT OF THE ARMY		ST. PAUL DISTRICT, CORPS OF ENGINEERS	
DESIGNED BY: T.J.S.		FLOOD CONTROL		MINNESOTA RIVER			
DRAWN BY: T.J.S.		CHASKA, MINNESOTA					
CHECKED BY: G.J.E.		CHASKA CREEK STAGE 2					
SUBMITTED BY:		BORING LOGS					
		85-81M THRU 85-88M					
CON. EX. D. SEALS		APPROVED BY:		DATE		MAY 1989	
CON. EX. D. SEALS		CHAS. PUGH, DISTRICT		SCALE		AS SHOWN	
				SHEET NO.		DACW37-89-B-0020	
				DRAWING NUMBER		M34-CH-P-10/8	
				SHEET		8 OF 92	



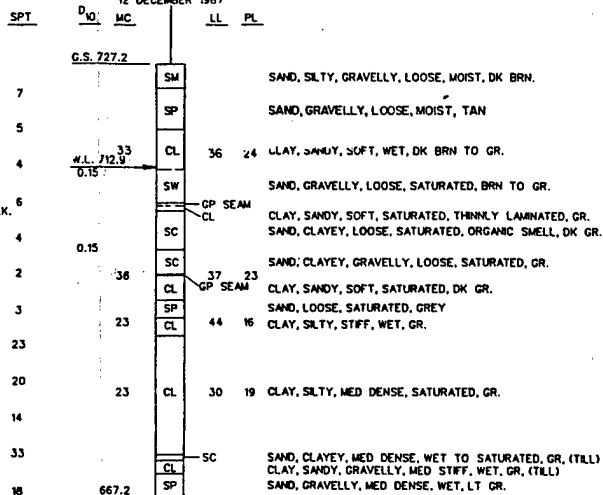
## 87-80M

10 DECEMBER 1987



## 87-81M

12 DECEMBER 1987



## 87-84A

14 DECEMBER 1987

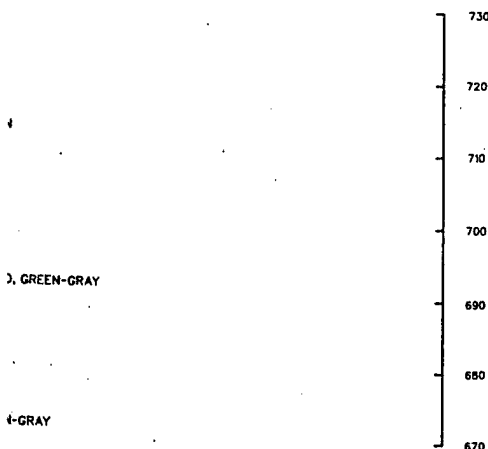
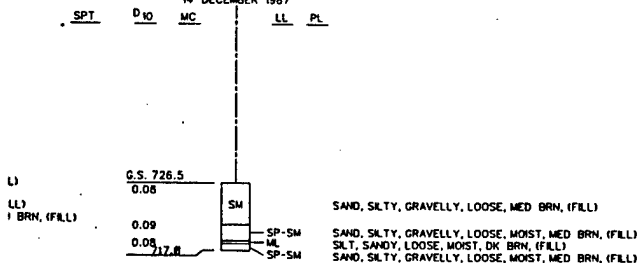
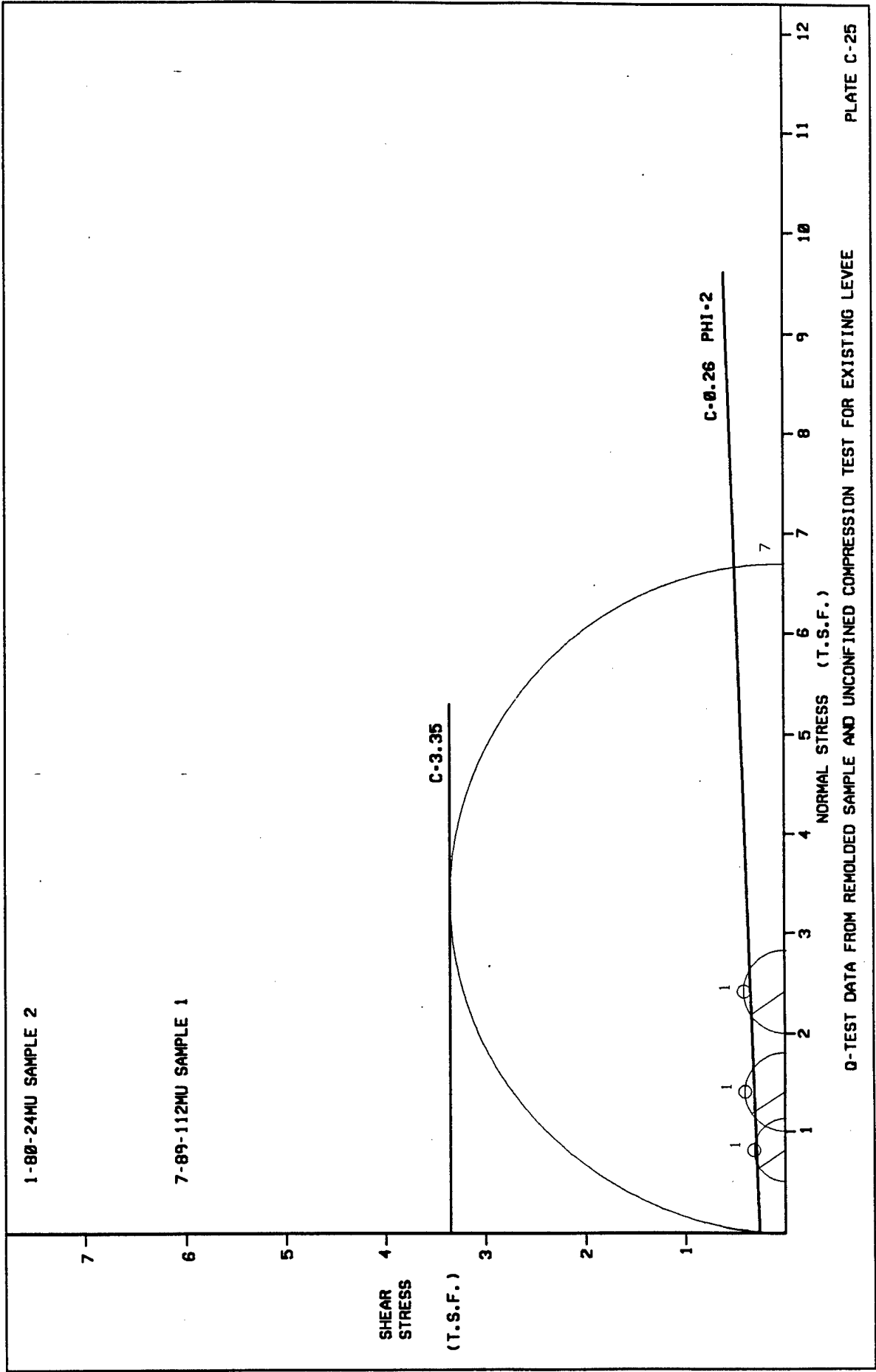
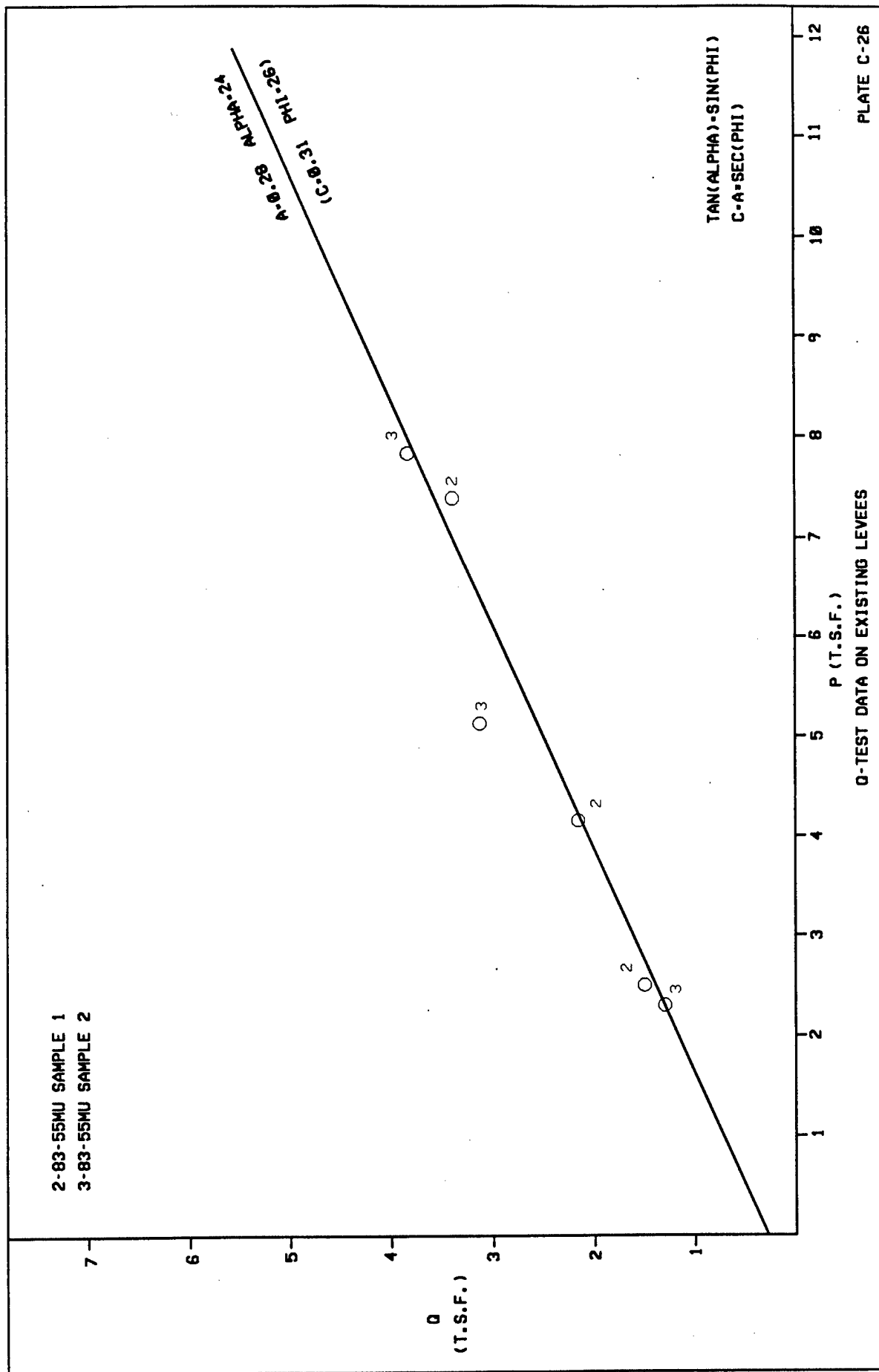


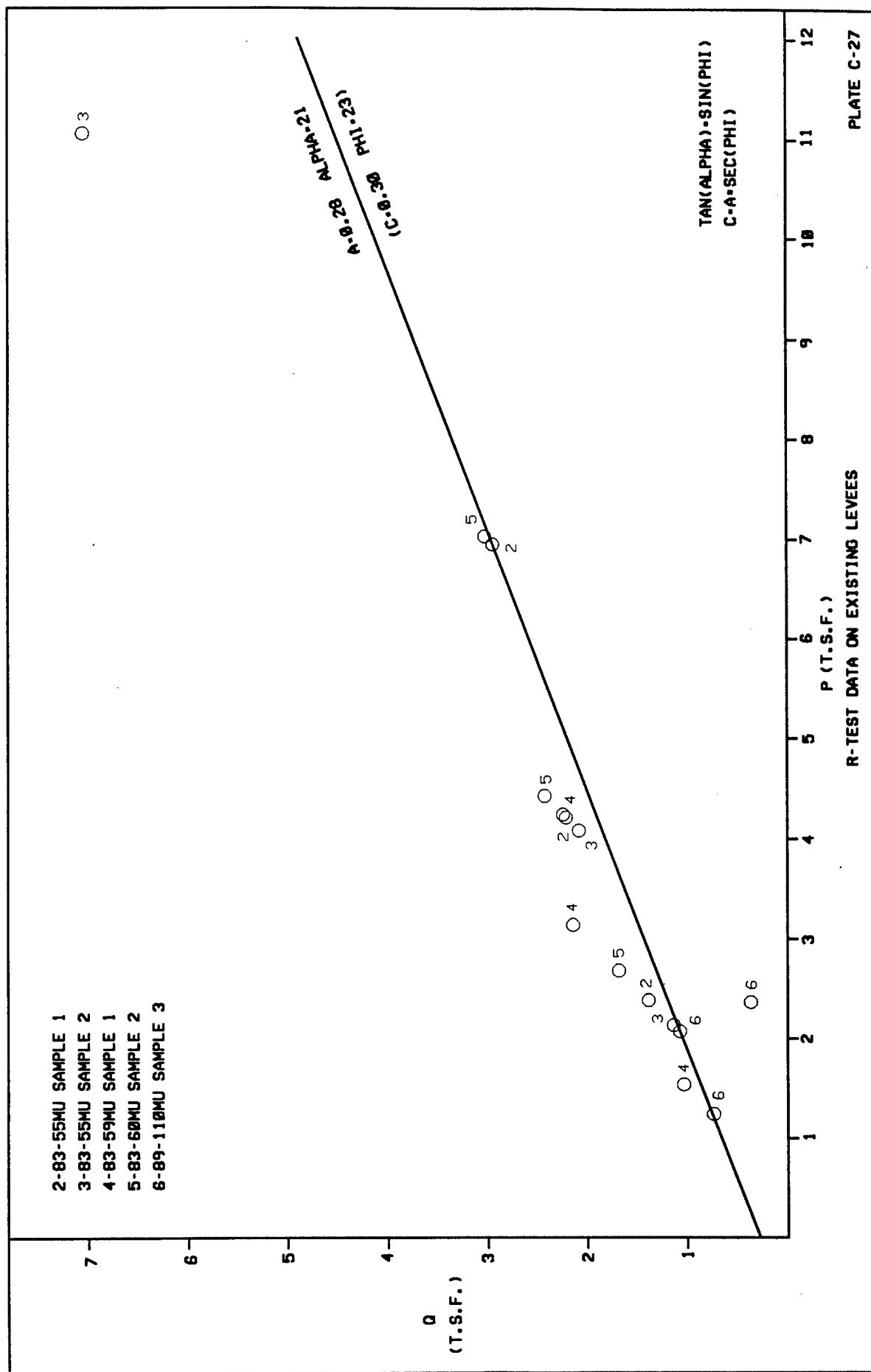
PLATE C-24

SYMBOL		DESCRIPTION		DATE	APPROVAL
DESIGNED BY: JRC DRAWN BY: RDC CHECKED BY: JRC SUBMITTED BY:					
DEPARTMENT OF THE ARMY ST. PAUL DISTRICT, CORPS OF ENGINEERS ST. PAUL, MINNESOTA					
FLOOD CONTROL CHASKA, MINNESOTA CHASKA CREEK STAGE 2 BORING LOGS 87-73M, 87-74M, 87-80M, 87-81M, 87-82A, 87-84A, 89-104M & 89-105M					
APPROVED BY:				DATE: MAY 1989	
AS SHOWN SPEC NO. DACW37-89-B-0020 DRAWING NUMBER M34-CH-P-10/9 SHEET 9 OF 92					

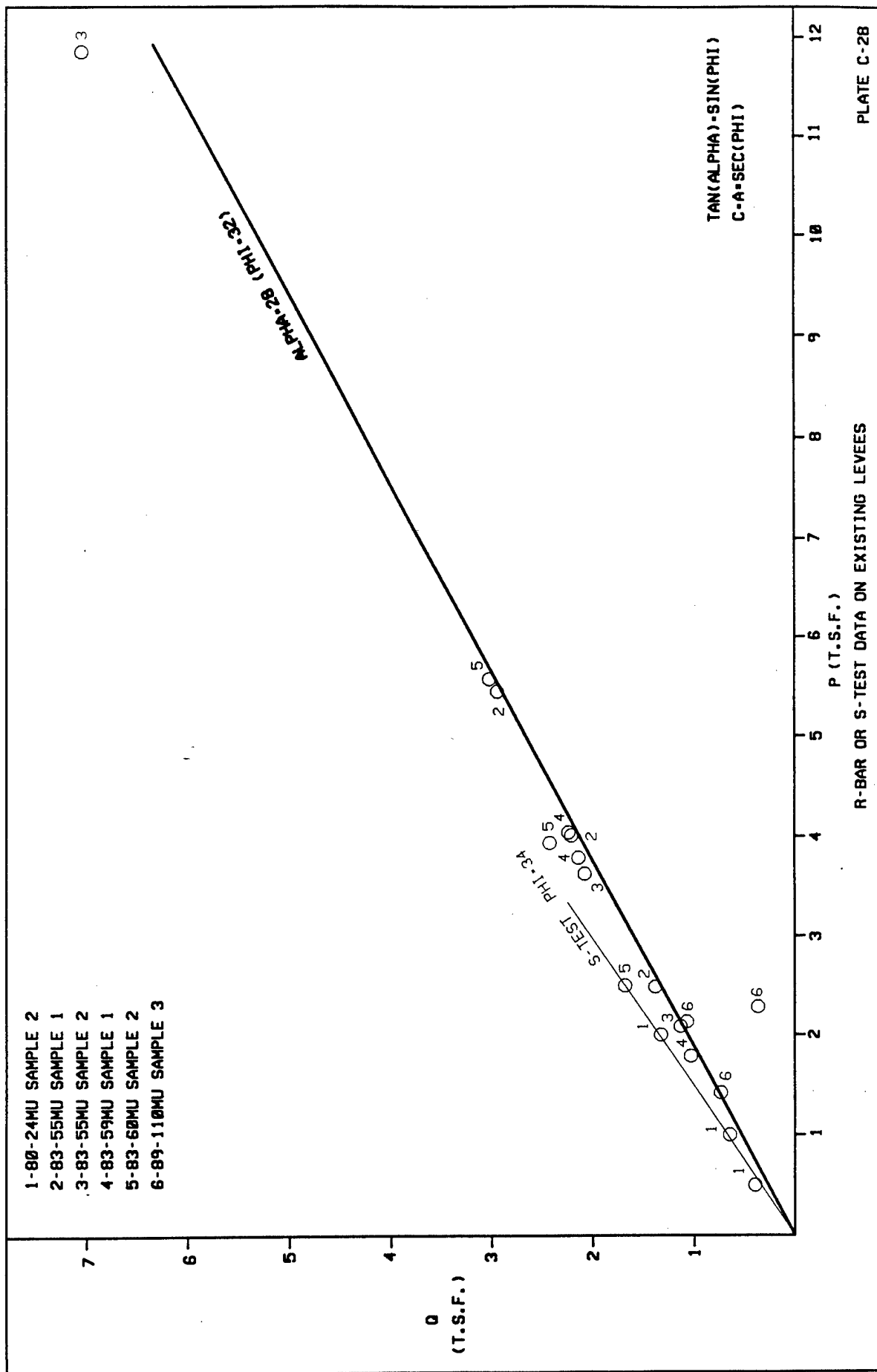
CONTRACT NO. DACW37-89-C-1004

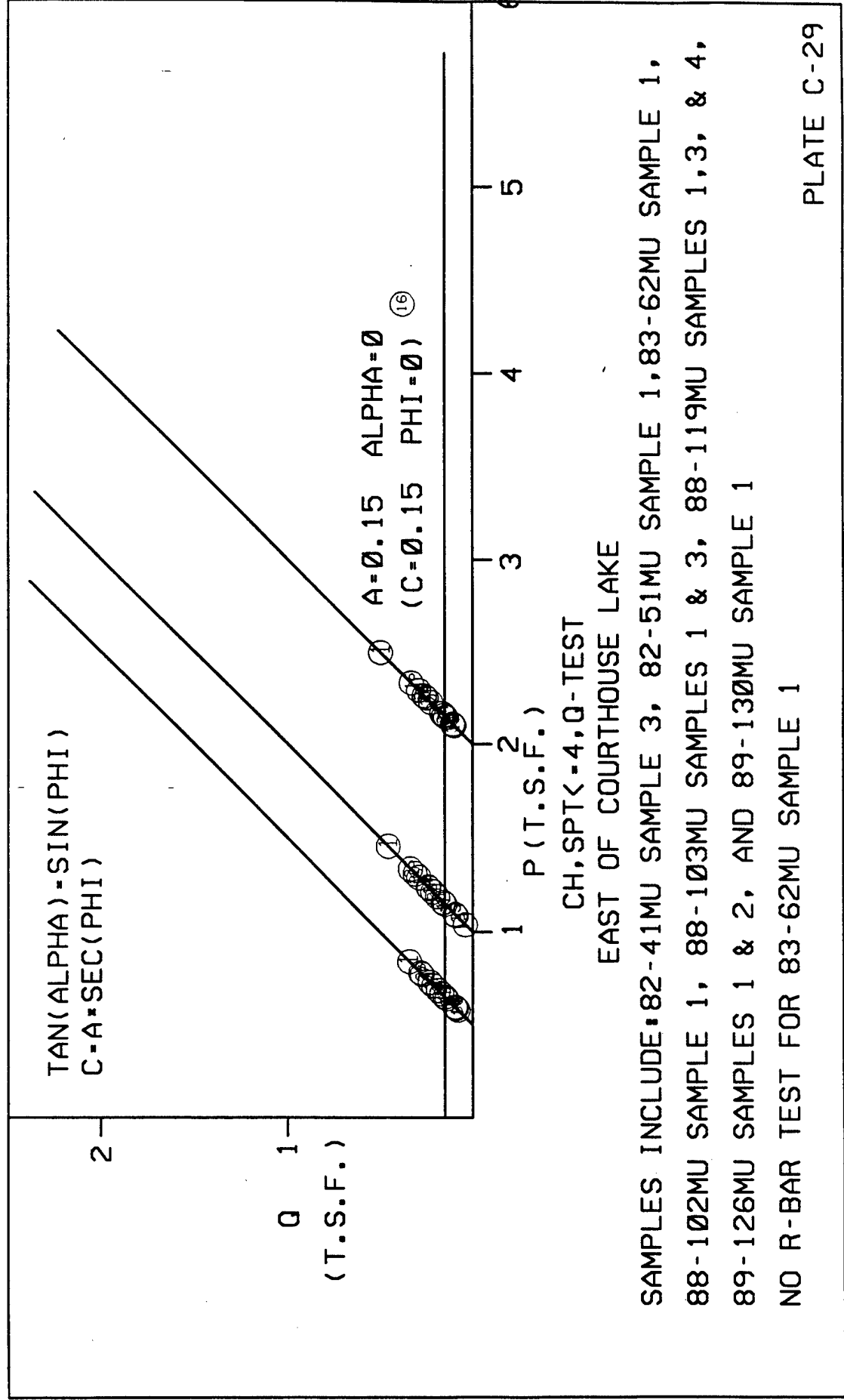


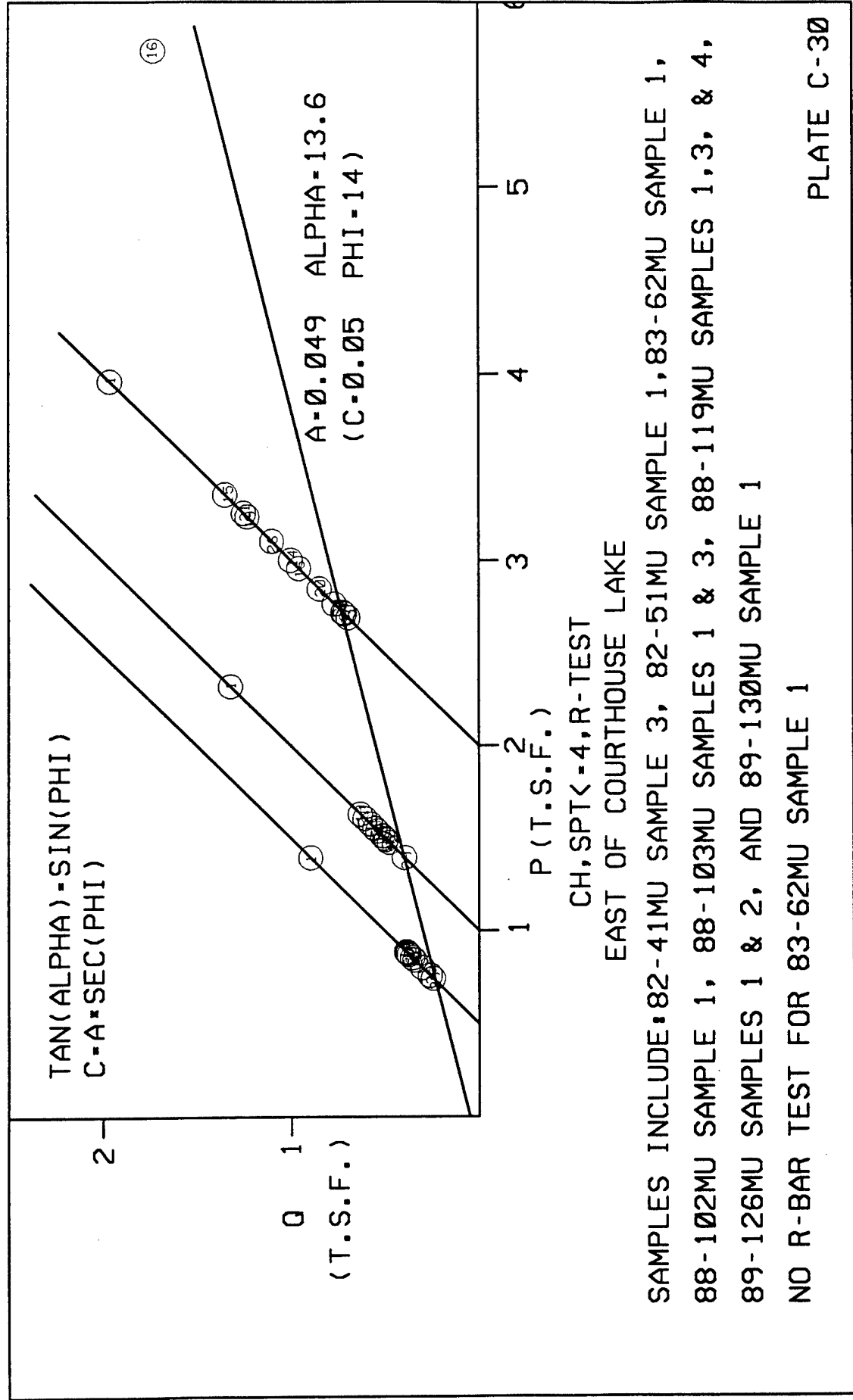


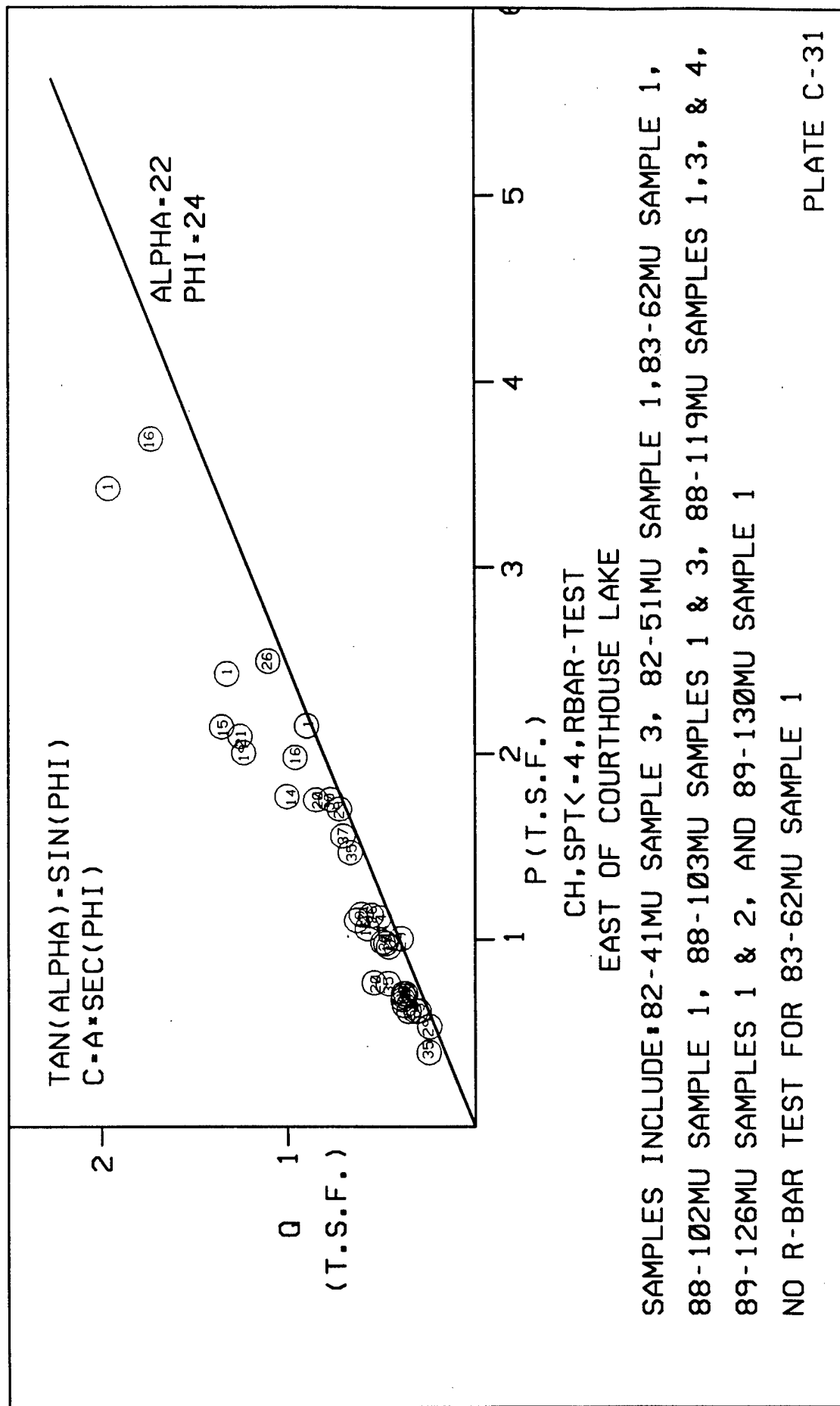


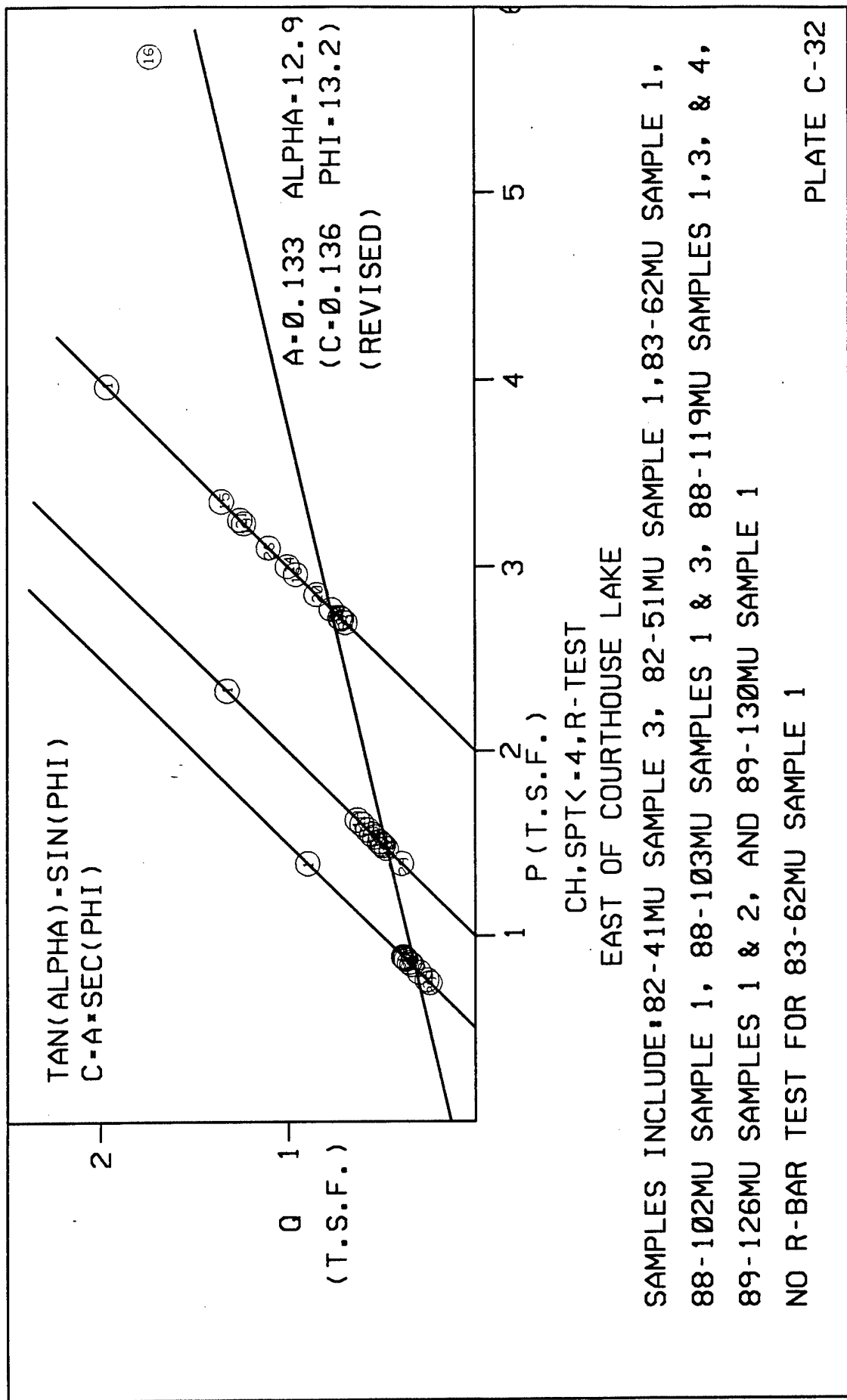


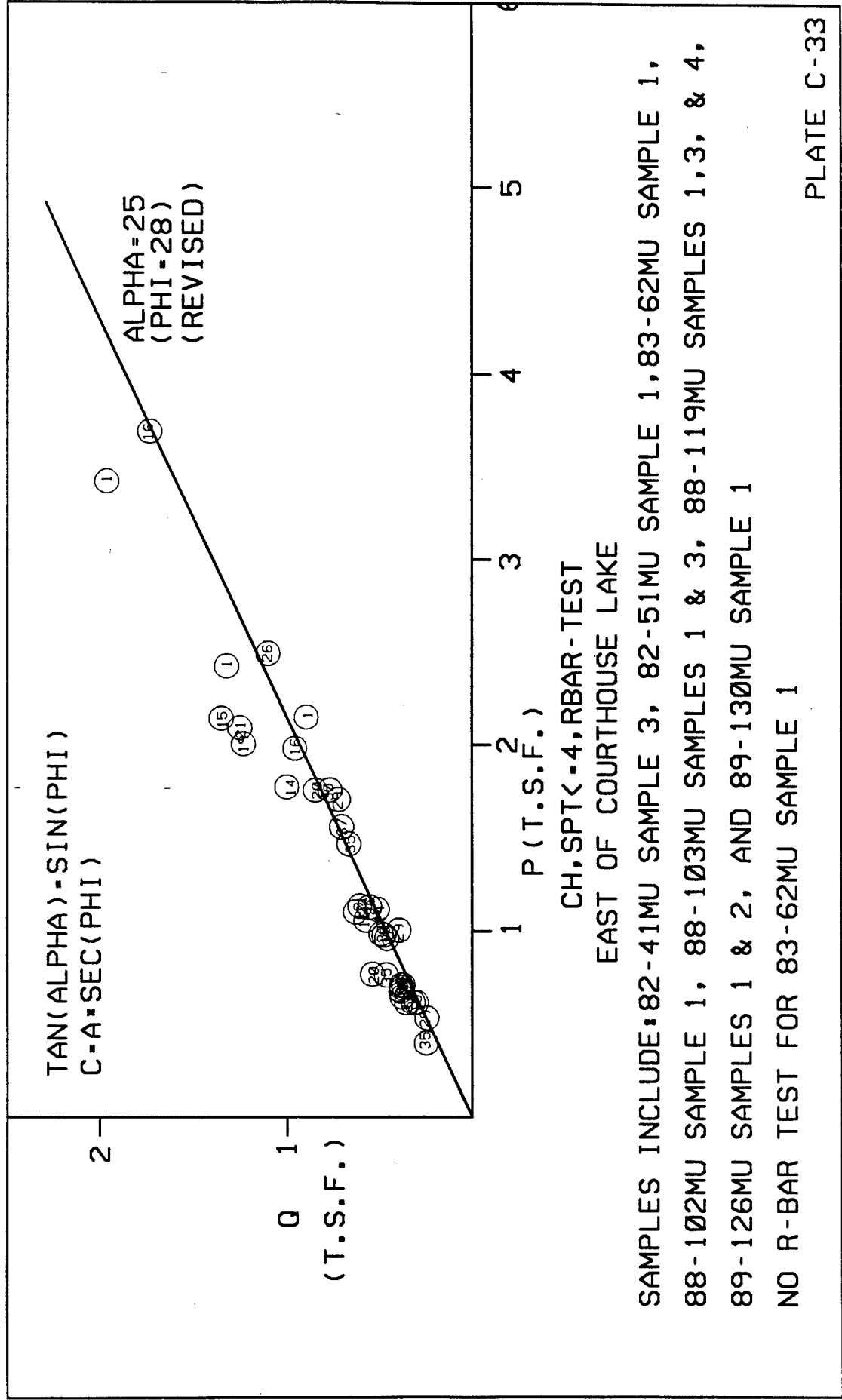


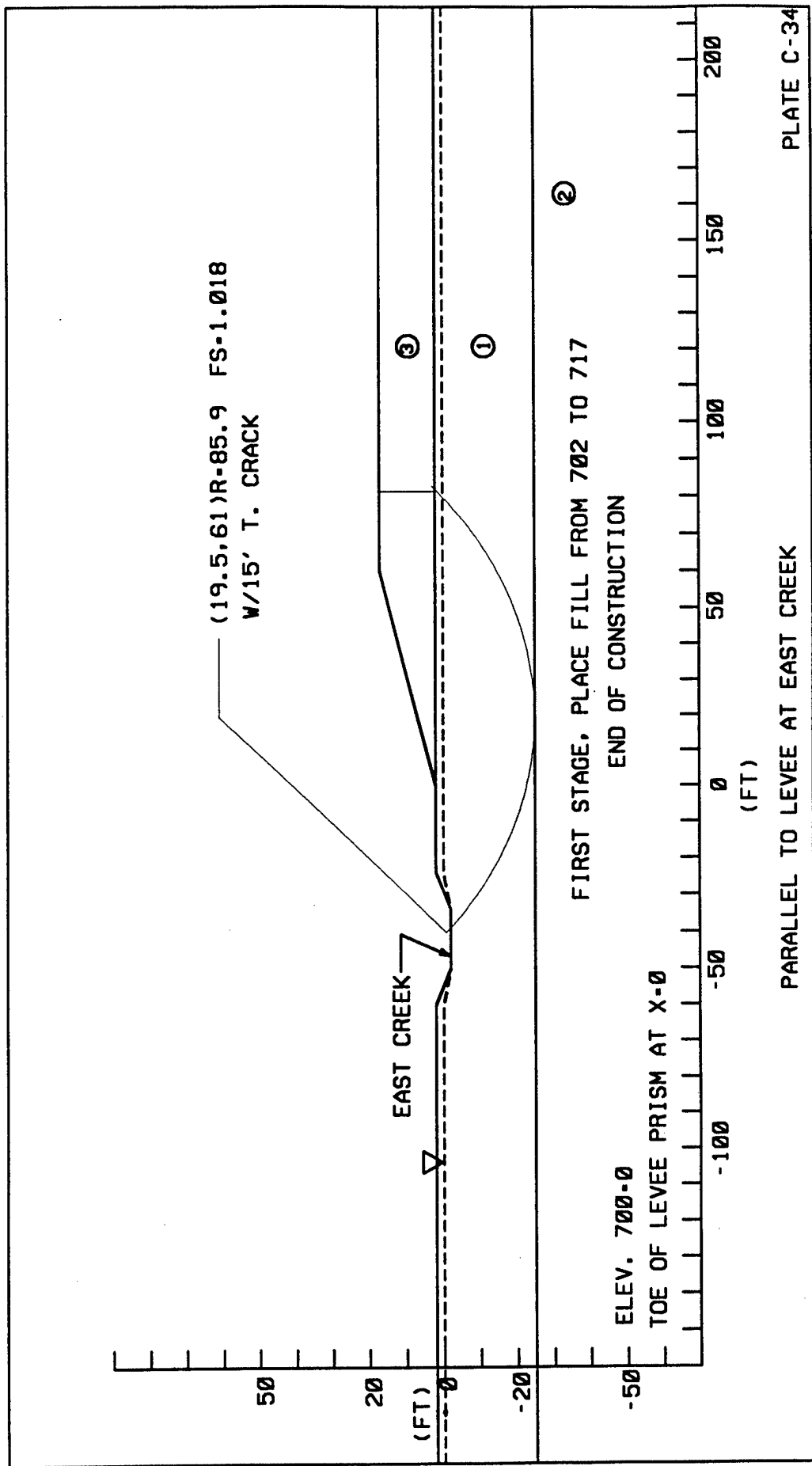


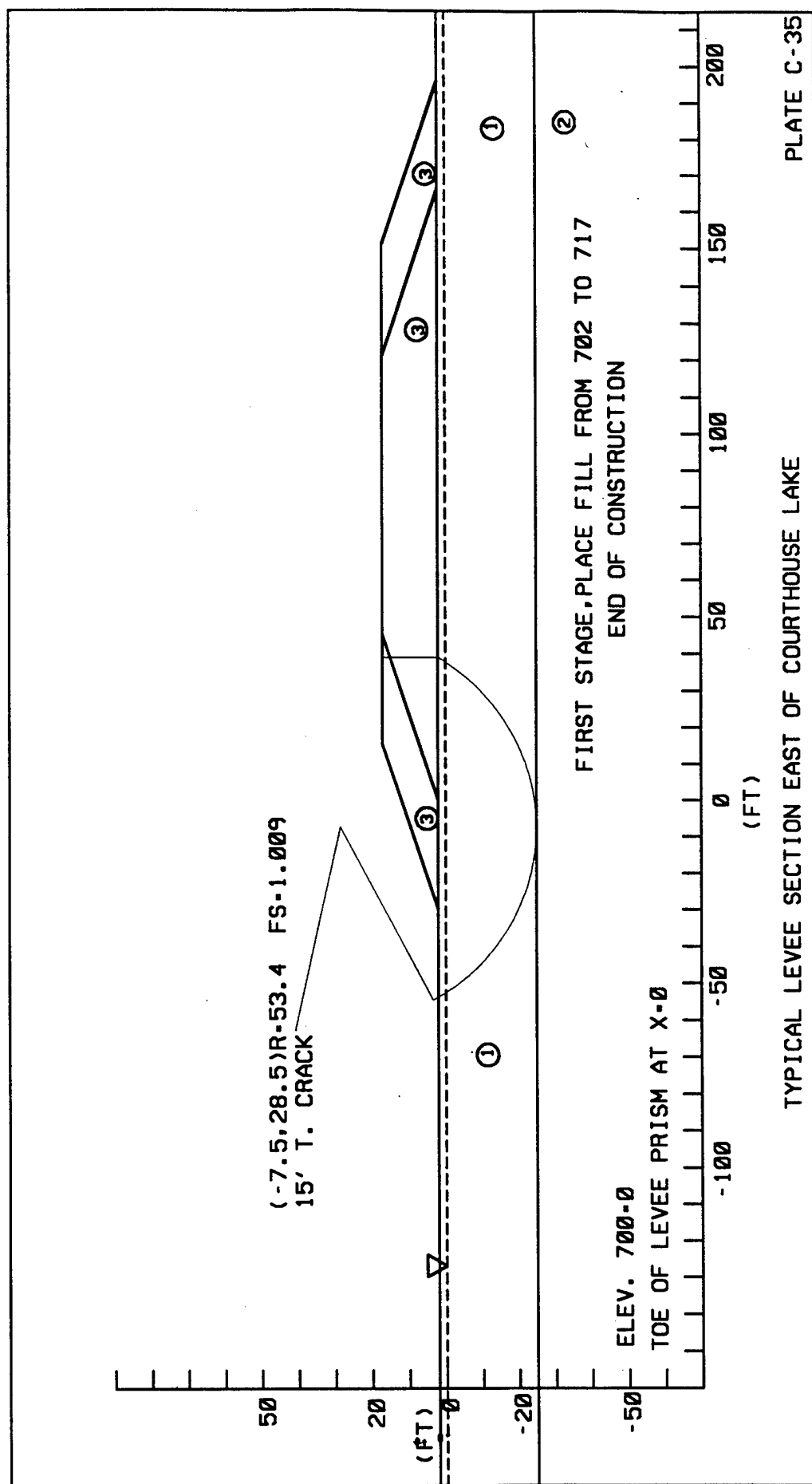




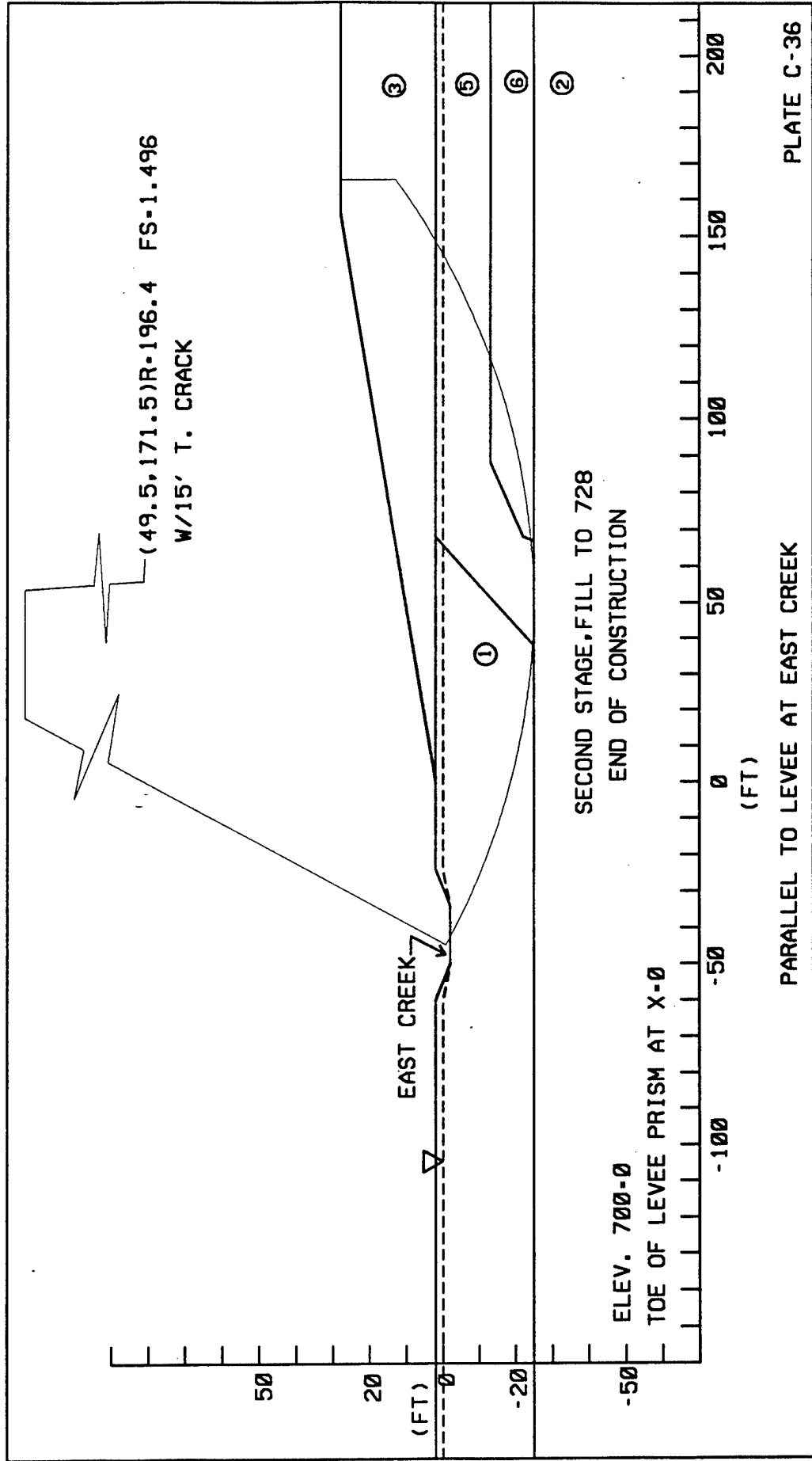


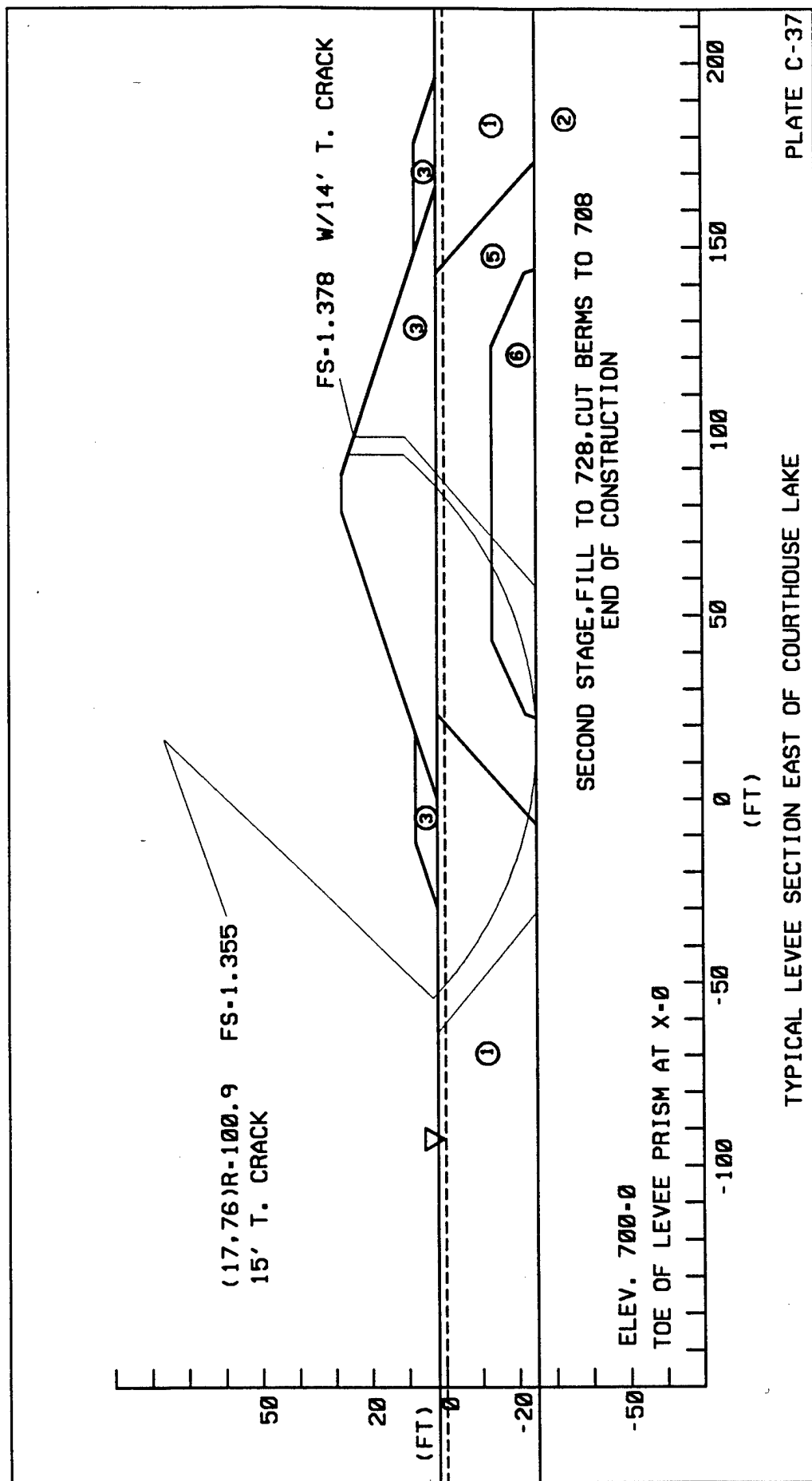


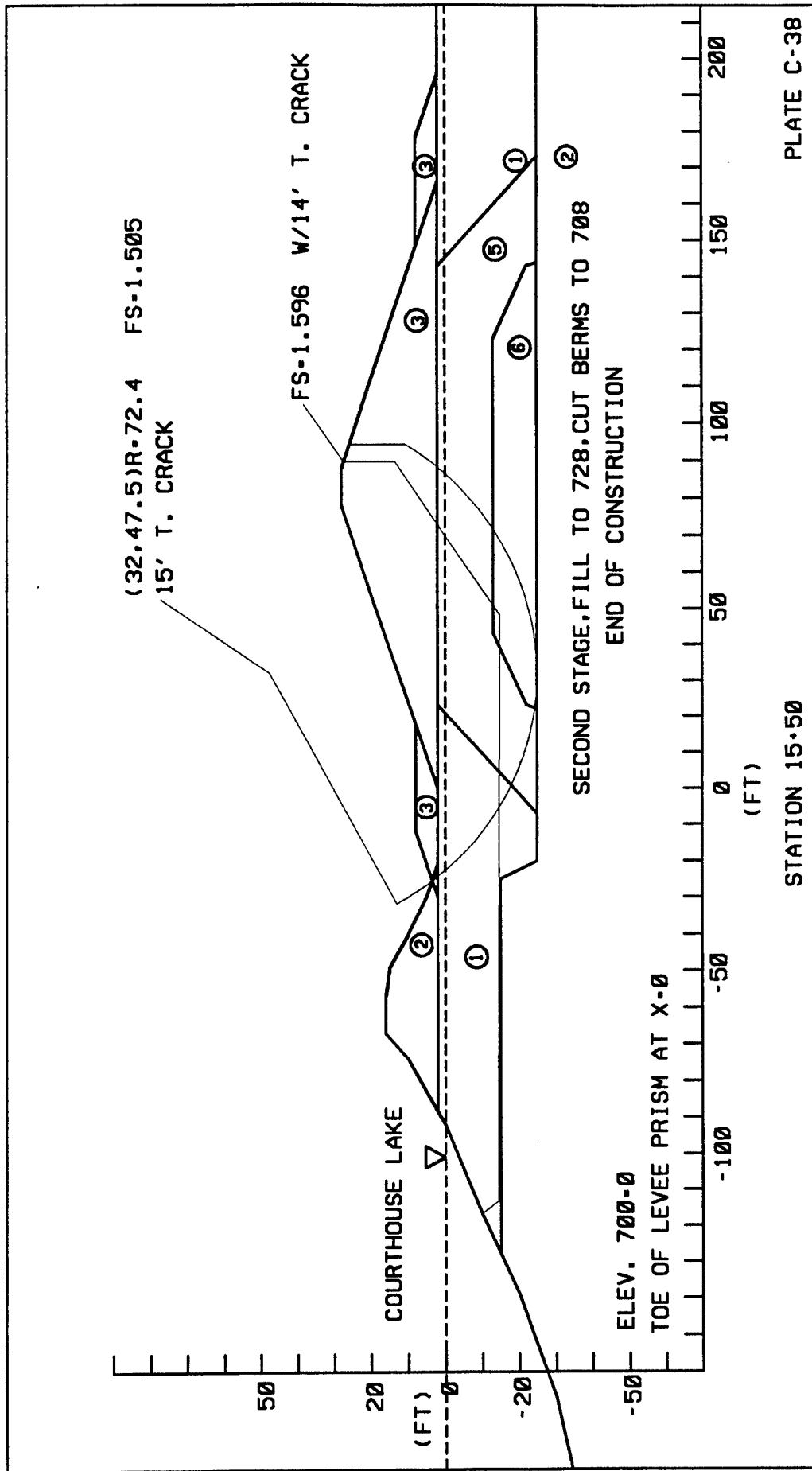


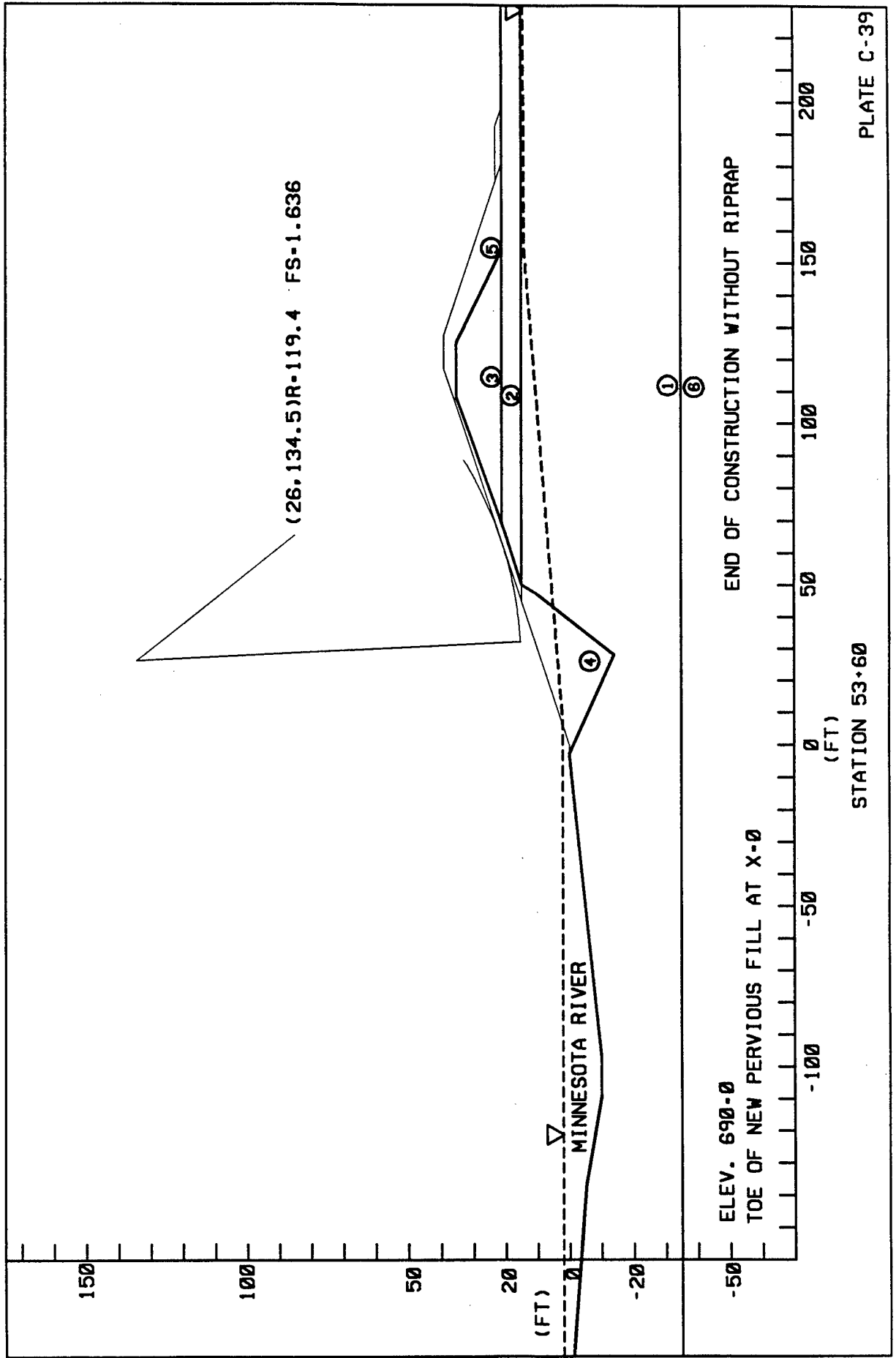


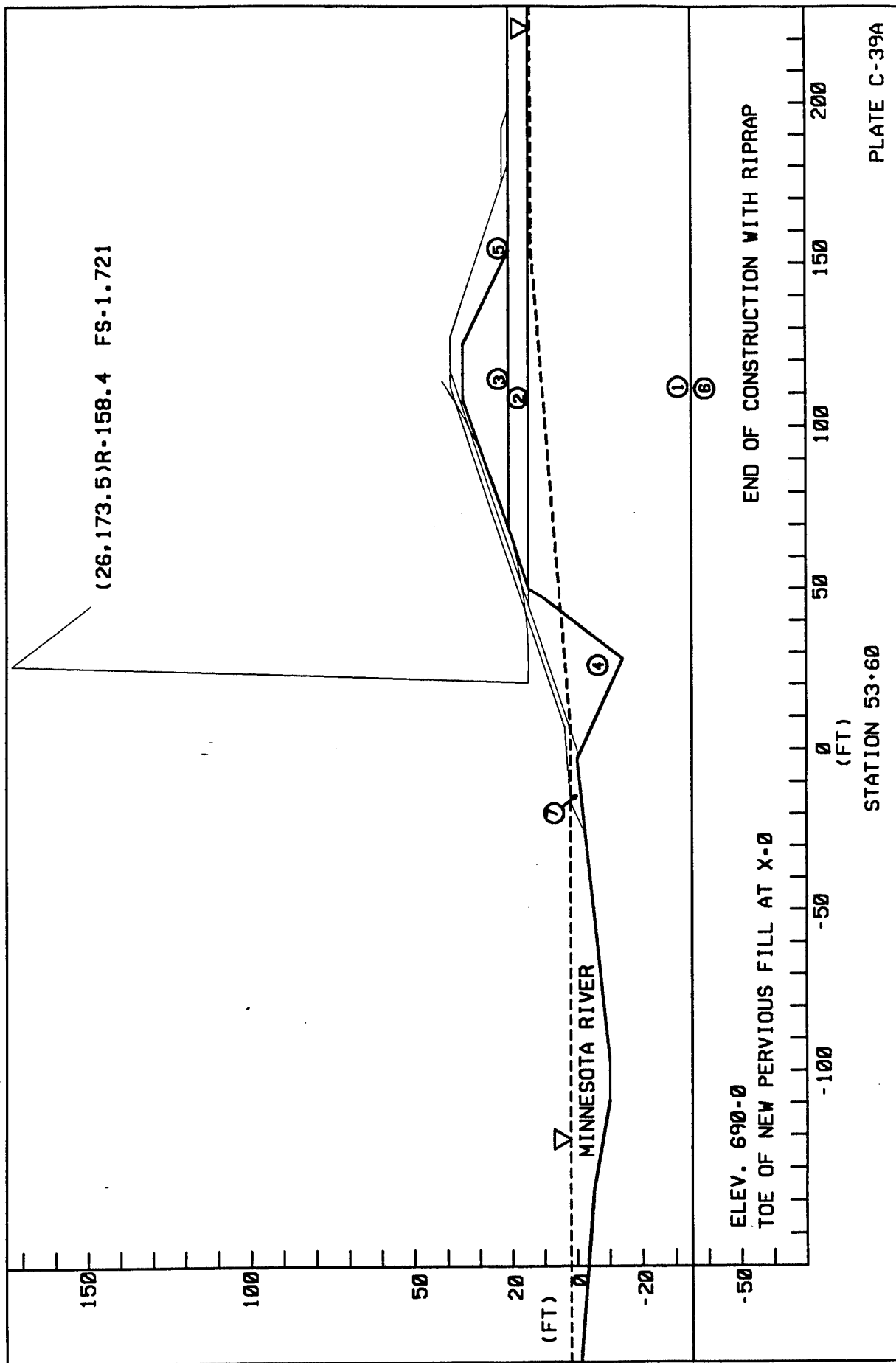


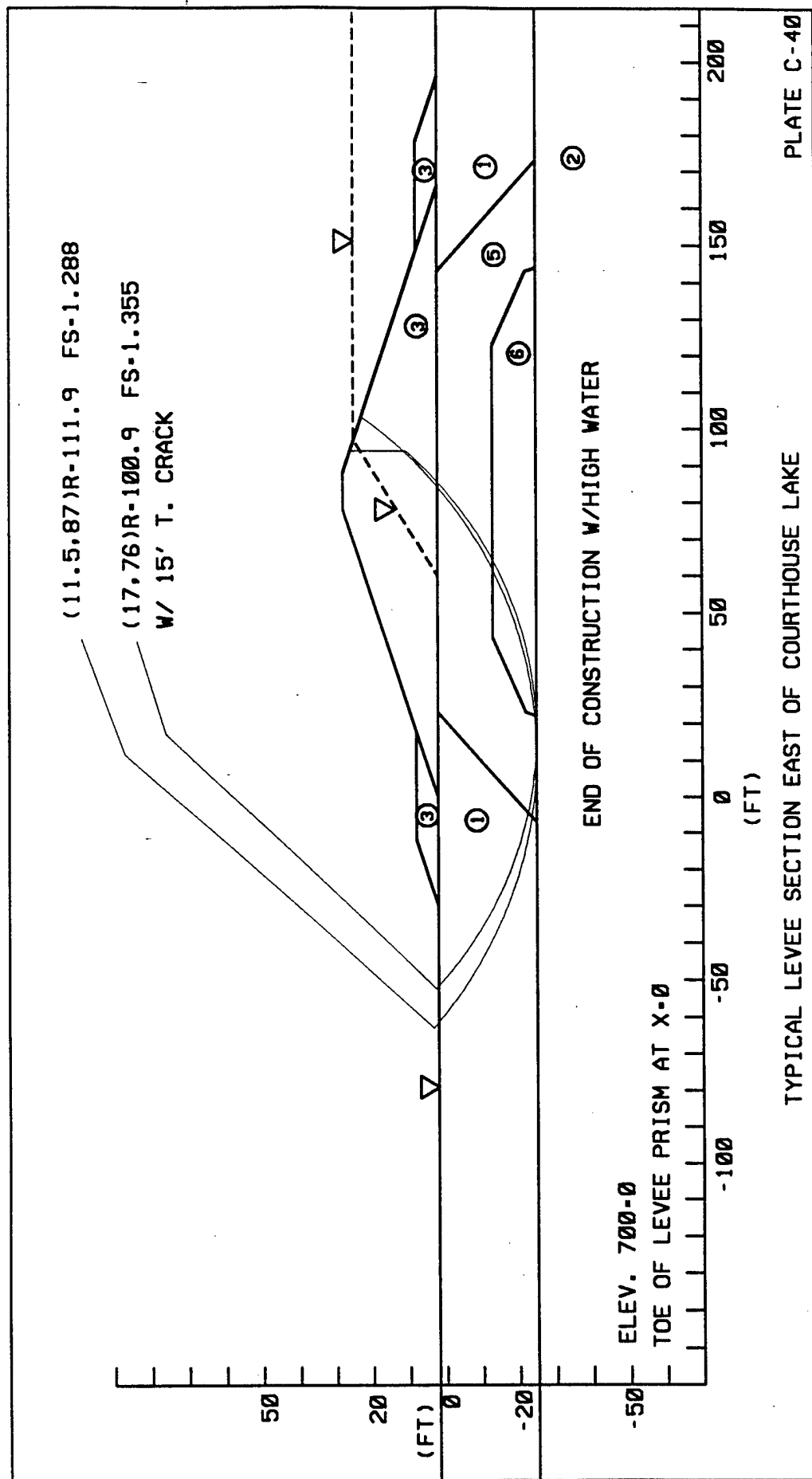


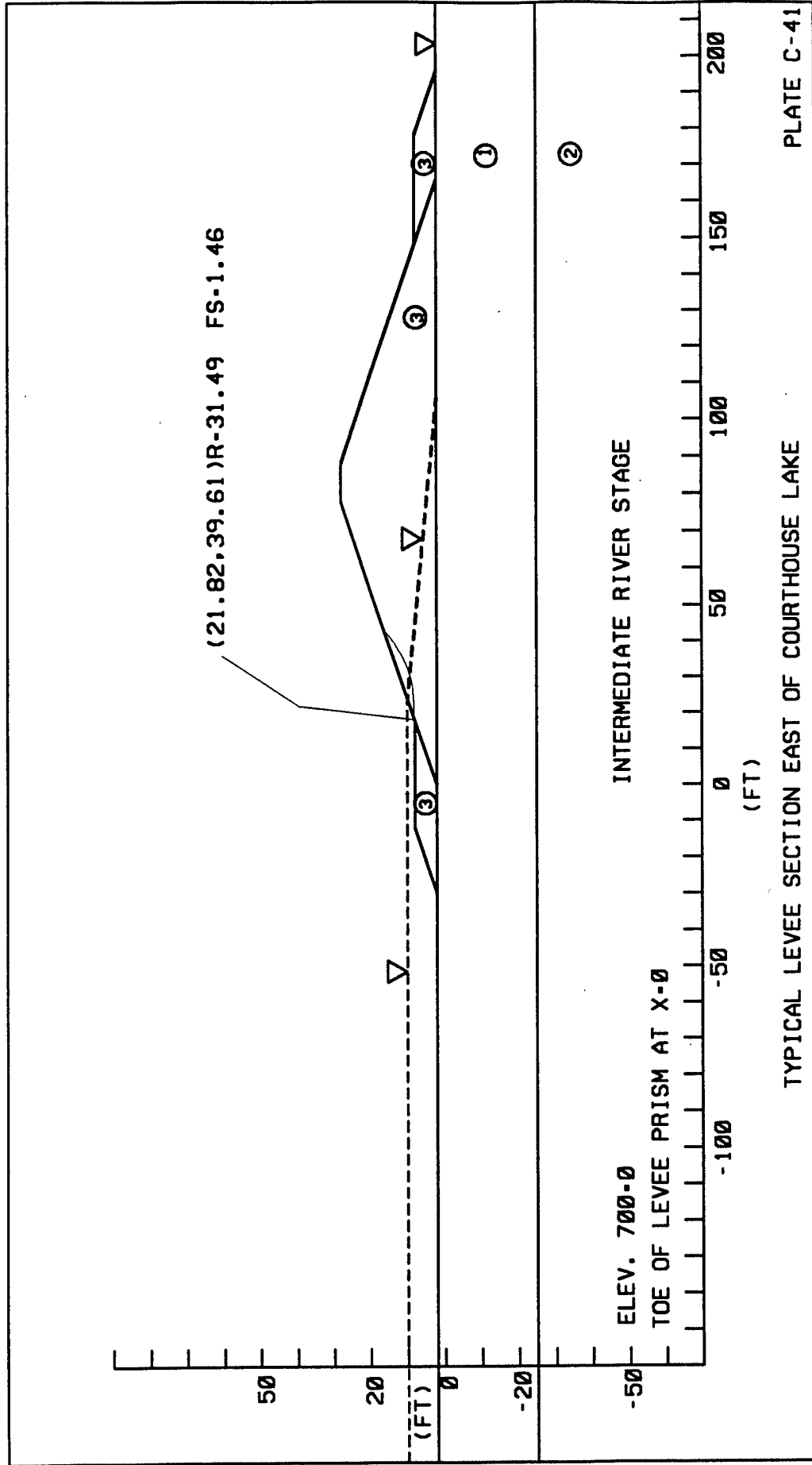


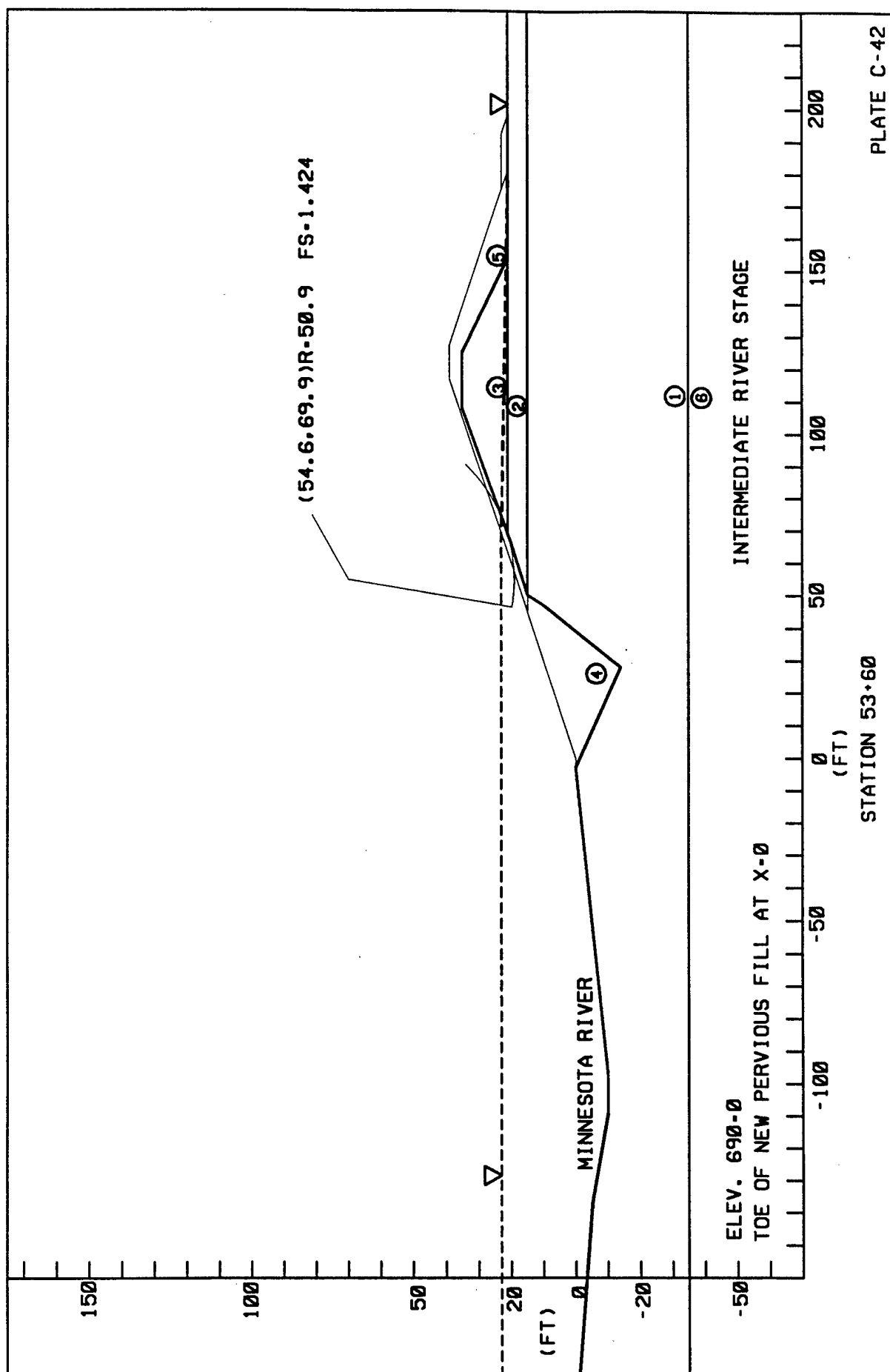














(12.5,90) R-113.9 FS-1.413

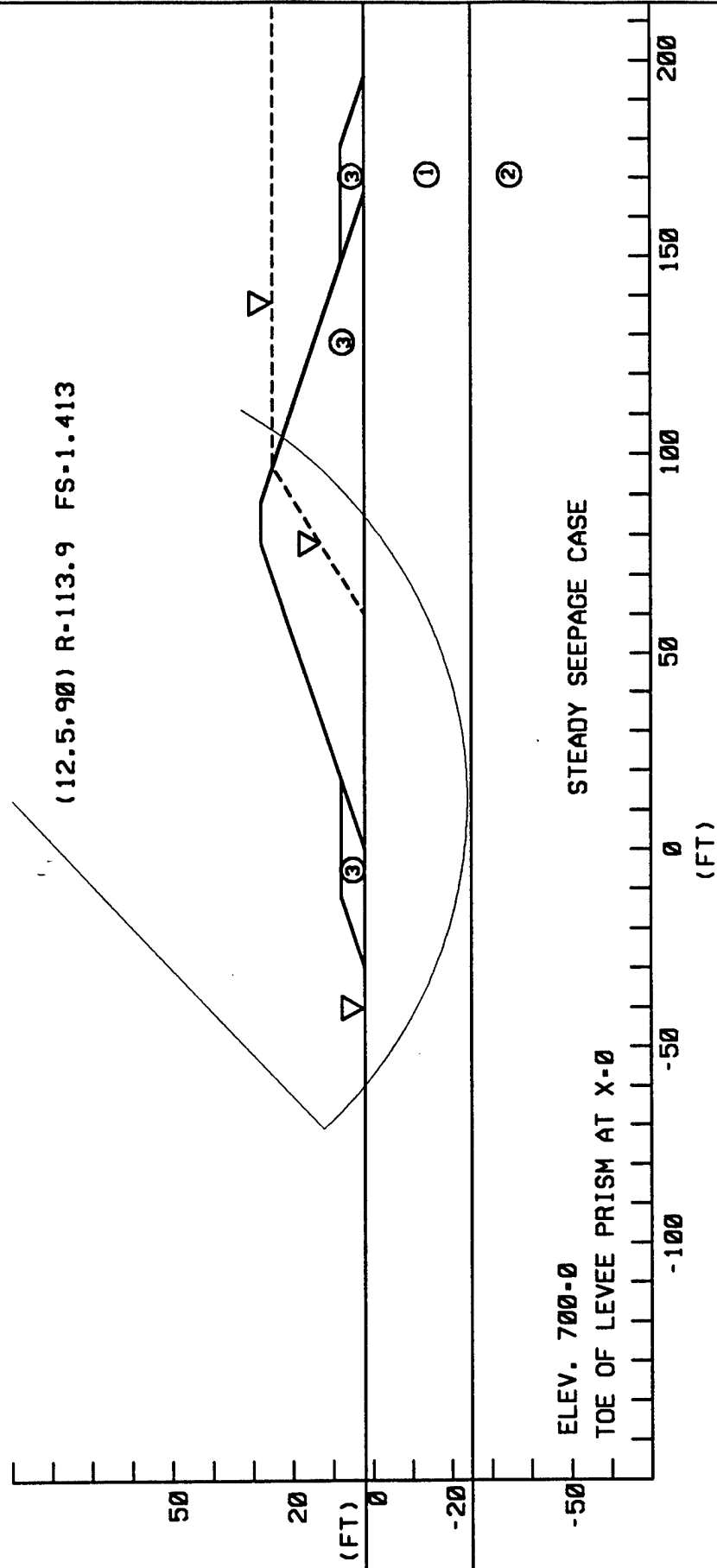
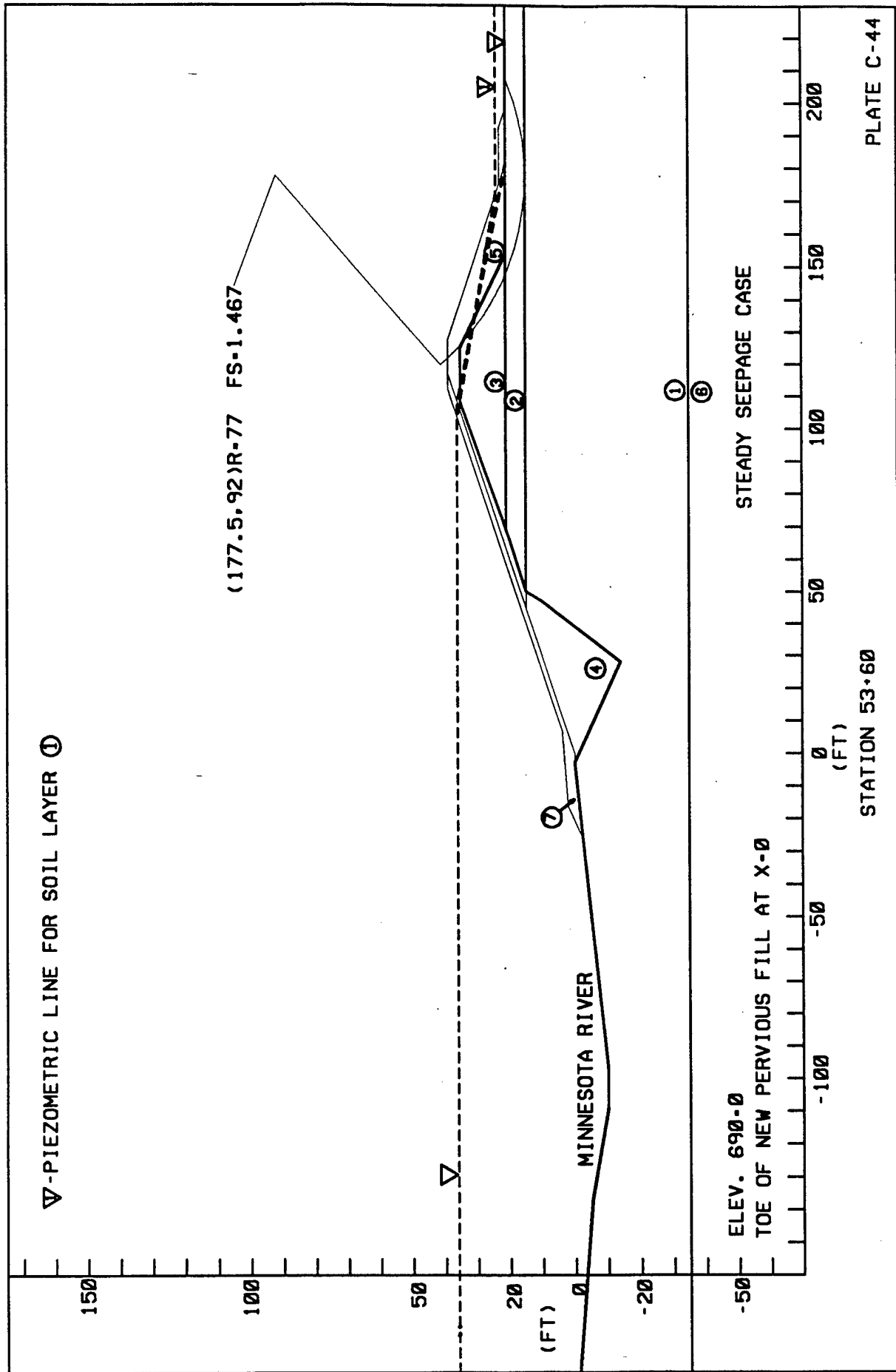


PLATE C-43



The following is a summary of the profile and piezometric lines used in the UTEXAS2 analyses adjacent to Courthouse Lake. The y-axis coordinate 0 is elevation 700 and the x-axis coordinate 0 is the levee prism toe.

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY,end of 1st stage construction  
check height of levee stable on soft soil, fill height=15'

PROFILE LINES

#1,soft native soils  
-500,2;500,2  
#2,dense native soils  
-500,-25;500,-25  
#3,levee fill  
-30,2;15,17;151,17;196,2  
PIEZOMETRIC LINE DATA  
-500,0;500,0

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY,staged construction  
end of construction(2nd stage of staged construction)

PROFILE LINES

#1,soft native soils  
-500,2;23,2  
#1,soft native soils  
143,2;500,2  
#2,dense native soils  
-500,-25;500,-25  
#3,levee fill  
-30,2;-12,8;18,8;78,28;88,28;148,8;196,2  
#5,consolidated soft soils 1  
-7,-25;3,-16;23,2;143,2;163,-16;173,-25  
#6,consolidated soft soils 2  
22,-25;23,-22;43,-13;123,-13;143,-22;144,-25  
PIEZOMETRIC LINE DATA  
-500,0;500,0

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY,staged construction,2nd stage  
end of construction,failure towards Courthouse Lake

PROFILE LINES

#1,soft native soils  
-128,-15;-117,-10;-92,0;-88.4,2;-21,2;0,2;23,2  
#1,soft native soils  
143,2;500,2  
#2,dense native soils  
-500,-50;-267,-50;-212,-40;-167,-30;-139,-20;-128,-15;-25,-15;-20,-25;500,-25  
#3,levee fill  
-25.5,3.5;-12,8;18,8;78,28;88,28;148,8;196,2  
#5,consolidated soft soils 1  
-7,-25;3,-16;23,2;143,2;163,-16;173,-25  
#6,consolidated soft soils 2  
22,-25;23,-22;43,-13;123,-13;143,-22;144,-25  
#2,dense native soils  
-88.4,2;-74,10;-67,16;-49,15;-40,10;-30,5;-21,2  
PIEZOMETRIC LINE DATA  
-500,-50;-267,-50;-212,-40;-167,-30;-139,-20;-128,-15;-117,-10;-92,0;500,0

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY, staged construction, 2nd stage  
end of construction with high water  
PIEZOMETRIC LINE DATA  
-500,2;0,2;60,2;97,25;500,25

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY, staged construction, 2nd stage  
steady seepage case, final height at 728, water surface at 725  
PIEZOMETRIC LINE DATA  
-500,2;0,2;60,2;97,25;500,25

The following is a summary of the profile and piezometric lines used in the  
UTEXAS2 analyses at East Creek with a failure parallel to the levee alignment.  
The y-axis coordinate 0 is elevation 700 and the x-axis coordinate 0 is the  
levee prism toe.

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY, end of 1st stage construction  
failure parallel to levee at East Creek, fill height=15'  
PROFILE LINES  
#1, soft native soils  
-500,2;-60,2;-50,-2;-34,-2;-24,2;500,2  
#2, dense native soils  
-500,-25;500,-25  
#3, levee fill  
0,2;60,17;500,17  
PIEZOMETRIC LINE DATA  
-500,0;-60,0;-50,-2;-34,-2;-24,0;500,0

LEVEE BY COURTHOUSE LAKE SLOPE STABILITY, staged construction, 2nd stage  
failure parallel to levee axis at East Creek crossing (1V to 4H levee slope)  
PROFILE LINES  
#1, soft native soils  
-500,2;-60,2;-50,-2;-34,-2;-24,2;68,2  
#2, dense native soils  
-500,-25;500,-25  
#3, levee fill  
0,2;60,17;500,17  
#5, consolidated soft soils 1  
38,-25;48,-16;68,2;500,2  
#6, consolidated soft soils 2  
67,-25;68,-22;88,-13;500,-13  
PIEZOMETRIC LINE DATA  
-500,0;-60,0;-50,-2;-34,-2;-24,0;500,0

The following is a summary of the profile and piezometric lines used in the  
UTEXAS2 analyses at station 53+60. The y-axis coordinate 0 is elevation 690  
and the x-axis coordinate 0 is the pervious fill in the river.

levee at 53+60 (DM stationing); end of construction  
elevation=690, riprap included  
PROFILE LINES

#1,natural grade sand aquifer  
 -500,-1;-190,-1;-137,-5;-109,-10;-97,-10;-62,-5;-25,-1.9;-3,0;28,-14;47,10;  
 50,15;500,15  
 #2,natural grade sand top blanket  
 50,15;66,20;68.8,21;500,21  
 #3,existing grade,existing levee fill  
 68.8,21;108,35;125,35;154,21  
 #4,new fill pervious  
 -3,0;0,0;45,15;50,15  
 #5,new fill;impervious  
 45,15;117,39;127,39,181,21  
 #6,underlying harder strata  
 -500,-35;500,-35  
 #7,riprap,with 10' bench  
 -25,-1.9;-16.2,2;6.75,3.83;112.75,39;117,39  
 #4,new pervious fill,berm for wells  
 175,23;192,23;198,21  
 PIEZOMETRIC LINE DATA  
 -500,2;6,2;154,14;500,14

levee at 53+60(DM stationing);steady seepage case  
 elevation=690,riprap included,water surface at 726

PIEZOMETRIC LINE DATA

1        62.4        piezometric line for all but sand aquifer and top blanket  
 -500,36;103.75,36;108,36;181,21;500,21  
 2        62.4        piezometric line for sand aquifer  
 -500,36;103.75,36;108,36;172,24;500,24

INTERPOLATION DATA USED TO SET PORE PRESSURES IN TOP BLANKET

Project:Chaska,Stage 4

BORING EVALUATION SHEET  
FOR UPLIFT

Date : 15-APR-1991

I BOTTOM ELEVATION OF BLANKET : 705.0  
II BOTTOM ELEVATION OF AQUIFER : 665.2Boring log 73-1M  
710.0 Top Elev.

## III BLANKET EVALUATION

	Soil Unit	Elevation From - To	Thick (z act.)	Kv FPM	Trans. Factor	Zb	Zt	Moist Density	Zt x D	Kvr FPM	Trans. Factor	Zbr
710.0			0.0			0	0.0		0.0	0	0	0
			0.0			0	0.0		0.0	0	0	0
700	10		0.0			0	0.0		0.0	0	0	0
	SM	709 - 708	1.0	0.002	0.4	0.4	1.0	62.6	62.6	0.0014	0.114	0.1
	CL	708 - 705	3.0	0.0008	1	3	3.0	62.6	187.8	0.00016	1	3
690	20	Sum "z" = 4.0				3.4	4.0		250.4			3.1

Value of Kv to use in  
calculating X3 below: 0.0008 fpm

## IV EVALUATION OF PERVIOUS AQUIFER

	Soil Unit	Elevation From - To	Thick d	D10	Source D10	Kh	Kh x d	Remarks
680	30	SP-SM	705 - 694.3	10.7	0.08 G	0.02	0.214	
		SM	694.3 - 690.5	3.8	A		0	
670	40	SP-SM	690.5 - 688	2.5	0.1 G	0.04	0.1	
		SP	688 - 682	6.0	0.14 G	0.09	0.54	
		ML	682 - 676.6	5.4	A		0	
660	50	SP	676.6 - 672.5	4.1	0.14 A	0.09	0.369	
		SW-SM	672.5 - 665.2	7.3	0.095 G	0.04	0.292	
		CL	665.2 - 664	0.0	A		0	

Sum [d] = 39.8 Sum [Kh x d] = 1.5

Source : "G" = Gradation, "P" = Permeability Test, "A" = Assumed

Kf = (sum [Kh x d]) / (sum [d]) = 0.038 fpm

EQUIVALENT BLANKET LENGTH (X3) (see note below)

$$(B-3) X3 = [(Kf \cdot d \cdot Zb) / (Kb)]^{0.5} = 80.24 \text{ ft.}$$

Note: Depending on boundary conditions "X3" may be defined differently.

PLATE C-49

15-APR-1991

## SEEPAGE BERM DESIGN - EM 1110-2-1913

$i_0 = 0.5$  Allowable gradient at levee toe  
 $i_1 = 0.8$  Allowable gradient at berm toe  
 $x_1 = 24.8$  ft. Distance to seepage entrance from riverside levee toe  
 $x_3 = 80.2$  ft. Distance to seepage exit from landside levee toe  
 $L_2 = 131.2$  ft. Levee width  
 $h_0 = 6.9$  ft. Head at landside toe of levee without berm  
 $H = 20.2$  ft. Total net head on levee  
 $K_f = 0.038$  fpm Permeability of pervious substratum  
 $K_{bl} = 0.0008$  fpm Permeability of landside top stratum  
 $Z_{bl} = 3.4$  ft. Transformed thickness of landside top stratum  
 $Z_t = 4$  ft. Actual thickness of landside top stratum  
 $D = 39.8$  ft. Effective thickness of pervious substratum  
 $Y_t = 52.5$  pcf Submerged unit weight of berm, impervious & semipervious  
 $Y_t = 57.5$  pcf Submerged unit weight of berm, sand & pervious  
 $Y_z = 62.5$  pcf Submerged unit weight of top stratum  
 $r = 0.625$   $i_0/i_1$   
 $c = 0.01247$   $[(K_{bl})/(K_f * Z_{bl} * d)]^{0.5}$   
 $s = 156$  ft.  $x_1 + L_2 =$  dist. to effective seepage entrance from levee toe  
 $A = 15.5$   $6 + 3sc(r+1)$   
 $h_a = 3.2$  ft. allowable head at toe of berm  $= i_1 * Z_t$

Calculate required berm width, "Xsp" semipervious berm  
 $X_{sp} = 88.2$  ft.  $(-A + [A^2 - 24 * (2+r) * (1+s*c - (H/h_a))]^{0.5}) / (2c * (2+r))$   
 Calculate head at landside toe of levee with berm  
 $h'_o = 8.4$  ft.  $h_a * [1 + c * (X_{sp}) + ((2+r)/6) * (c * (X_{sp}))^2]$   
 Calculate required thickness of berm  
 $t = 4.3$  ft.  $(h'_o - i_0 * Z_t) / (1 + i_0)$

Calculate required berm for: "Xp" pervious berm with collector  
 $X_p = 61.6$  ft.  $x_3 * \log(e) * (h'_o/h_a)$   $h'_o = h_0$   
 $h'_o = 6.9$  ft.  $= h_0 = (H * x_3) / (s + x_3)$   
 $t = 2.8$  ft.  $[h'_o - Z_t * (Y'_z / F * Y_w)] / [1 + (Y'_t / F * Y_w)]$   $F = 1.6$   
 $Q_b = 0.069$  cfm  $[(K_f * H * d) / (s + x_3)] * [1 - \exp(-X_p/x_3)]$   
 $Q_b = 0.52$  gpm flow per ft. of levee

Calculate required berm for: "Xs" sand berm  
 $X_s = 79.3$  ft.  $(1/3) * (X_p + 2X_{sp})$   
 $h'_o = 7.7$  ft.  $h_a * [1 + c * X_s + (2+r)/6 * (c * X_s)^2]$   
 $t = 3.3$  ft.  $[h'_o - Z_t * (Y'_z / F * Y_w)] / (1 + (Y'_t / F * Y_w))$

Calculate required berm for: "XI" Impervious berm  
 $X_I = 270.1$  ft.  $x_3 * [(H/h_a) - 1] - s$   
 $h'_o = 14.0$  ft.  $H * [(x_3 + X_I) / (s + x_3 + X_I)]$   
 $t = 7.5$  ft.  $[h'_o - Z_t * (Y'_z / F * Y_w)] / (1 + (Y'_t / F * Y_w))$

type of Berm	Width	t	h'o	Thick Berm Crown	Design Slope 1 On	Thick Levee Toe	25 % increase in size Berm Crown	Levee Toe	Const. cu. yd. per 100'	Slope 1 on
Imper	270	7.5	14.0	2.0	75	7.5	2.50	9.4	6,441	39
Semip	88	4.3	8.4	2.0	75	4.3	2.50	5.3	1,439	31
Sand	79	3.3	7.7	2.0	75	3.3	2.50	4.1	1,072	48
P w/C	62	2.8	6.9	2.0	75	2.8	2.50	3.5	757	60



CHASKA STAGE 4,/USR/jrc/chaska/STAGE4/WELLAT706/w73-1f  
 741-SF-F5050 DESIGN FOR INFINITE SYSTEM OF RELIEF WELLS  
 WELL DESIGN, RISer at 706  
 54+00  
 8" WELL

D	FK	X3	S	H	WHT	RL
39.800	0.038	80.200	156.000	20.200	-3.000	2.750

DIA	RW	FREE	WD1	CODE	SAFE	F
8.000	0.530	3.000	0.000	0.000	1.000	1.700

LAYER	ZT(I)	GAM(I)
1	4.000	125.000

FS= 0.585

WD	SP	QW R	V HW	HAV HAV1	TAV TAV1	QUEW QSW	QS	HM1 HAVB	TM1 TM
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
0.400	47.085	51. 115.	0.328 -2.931	1.744 4.676	1.028 1.028	0.980 0.177	1.156	5.292 1.254	1.164 1.164
0.500	53.807	60. 112.	0.384 -2.935	1.623 4.558	0.857 0.857	1.003 0.162	1.164	5.295 1.145	0.996 0.996
0.600	60.183	68. 110.	0.436 -2.937	1.547 4.484	0.743 0.743	1.017 0.152	1.169	5.298 1.076	0.878 0.878
0.700	66.263	76. 109.	0.485 -2.939	1.496 4.435	0.661 0.661	1.027 0.145	1.173	5.299 1.031	0.790 0.790
0.800	72.085	83. 109.	0.531 -2.940	1.462 4.402	0.599 0.599	1.034 0.141	1.175	5.300 1.000	0.722 0.722
0.900	77.675	90. 108.	0.574 -2.940	1.439 4.379	0.551 0.551	1.038 0.138	1.176	5.301 0.979	0.667 0.667
1.000	83.057	96. 108.	0.616 -2.941	1.423 4.363	0.512 0.512	1.041 0.136	1.177	5.301 0.965	0.622 0.622

file:/usr2/jrc/chaska/STAGE4/well/T73-1f.w20  
 15-APR-1991  
 pg.293 of TM3-424

W-effective screen penetration in a stratified foundation  
 W|-well screen length  
 dn-thickness of nth soil layer  
 kh\_n-horizontal permeability of nth soil layer  
 kv\_n-vertical permeability of nth soil layer  
 d|n-transformed isotropic thickness of nth soil layer  
 k|n-transformed isotropic permeability of nth soil layer  
 D|-thickness of transformed, homogeneous, isotropic foundation  
 K|-effective permeability of transformed foundation

$$d|n = dn * \sqrt{kh_n / kv_n}$$

$$k|n = \sqrt{kh_n * kv_n}$$

$$D| = \sqrt{\sum(dn * kh_n) * \sum(dn / kv_n)}$$

$$K| = \sqrt{\sum(dn * kh_n) / \sum(dn / kv_n)}$$

$$W = \sum(\text{from } 0 \text{ to } W|)(dn * kh_n) / K|$$

WP=well screen penetration into layer(100%=1;50%=.5;etc.)

$$W/D| = ([\sum(WP * dn * kh_n)] / [\sum(dn * kh_n)])$$

# of soil layers n	thickness of soil layers dn	kh_n	kv_n	d n	k n	dn*kh_n	dn/kv_n	WP	WP* dn*kh_n		
1	10.7	0.02	0.02	10.7	0.02	0.214	535	0.8	0.179	8.95	
2	3.8	0	0		0	0		1	0	3.8	
3	2.5	0.04	0.04	2.5	0.04	0.1	62.5	1	0.1	2.5	
4	6	0.09	0.09	6	0.09	0.54	66.6667	1	0.54	6	
5	5.4	0	0		0	0		1	0	5.4	
6	4.1	0.09	0.09	4.1	0.09	0.369	45.5556	1	0.369	4.1	
7	7.3	0.04	0.04	7.3	0.04	0.292	182.5	1	0.292	7.3	
8	0	0	0		0	0		0	0	0	
9	0	0	0		0	0		0	0	0	
10	0	0	0		0	0		0	0	0	
11	0	0	0		0	0		0	0	0	
12	0	0	0		0	0		0	0	0	
13	0	0	0		0	0		0	0	0	
14	0	0	0		0	0		0	0	0	
15	0	0	0		0	0		0	0	0	
16	0	0	0		0	0		0	0	0	
39.8		sums=					1.515	892.222	1.48		38.05
										screen	
										length	

Project:Chaska,Stage 4

BORING EVALUATION SHEET  
FOR UPLIFT

Date : 15-APR-1991

I BOTTOM ELEVATION OF BLANKET : 664.0  
II BOTTOM ELEVATION OF AQUIFER : 576.0Boring log 73-1M  
710.0 Top Elev.

## III BLANKET EVALUATION

710.0	-----	0	Soil Unit	Elevation From - To	Thick (z act.)	Kv FPM	Trans. Factor	Zb	Zt	Moist Density	Zt x D	Kvr FPM	Trans. Factor	Zbr
			SM	709 708	1.0	0.002	0.4	0.4	1.0	62.6	62.6	0.0014	0.114	0.1
			CL	708 705	3.0	0.0008	1	3	3.0	62.6	187.8	0.00016	1	3
700		10	SP-SM	705 694.3	10.7	0.02	0.04	0.428	10.7	62.6	669.8	0.02	0.008	0.1
			SM	694.3 690.5	3.8	0.002	0.4	1.52	3.8	62.6	237.9	0.0014	0.114	0.4
			SP-SM	690.5 688	2.5	0.04	0.02	0.05	2.5	62.6	156.5	0.04	0.004	0
690		20	SP	688 682	6.0	0.09	0.009	0.053	6.0	62.6	375.6	0.09	0.002	0
			ML	682 676.6	5.4	0.0016	0.5	2.7	5.4	62.6	338.0	0.0003	0.533	2.9
			SP	676.6 672.5	4.1	0.09	0.009	0.036	4.1	62.6	256.7	0.09	0.002	0
680		30	SW-SM	672.5 665.2	7.3	0.04	0.02	0.146	7.3	62.6	457.0	0.04	0.004	0
			CL	665.2 664	1.2	0.0008	1	1.2	1.2	62.6	75.1	0.00016	1	1.2
					Sum "z" =	45.0		9.5	45.0		2817.0			7.8
670		40	Value of Kv to use in calculating X3 below: 0.0008 fpm											

## IV EVALUATION OF PERVIOUS AQUIFER

660	50	Soil Unit	Elevation From - To	Thick d	D10	Source D10	Kh	Kh x d	Remarks
		SP-SM	664 644.5	19.5	0.12	G	0.08	1.56	
		SP-SM	644.5 626	18.5	0.17	G	0.14	2.59	
650	60	GP	626 607	19.0	0.21	G	0.22	4.18	
		SP	607 598	9.0	0.19	G	0.18	1.62	
		SP	598 576	22.0	0.12	G	0.08	1.76	
640	70	CL-CH	576 574	0.0		A		0	
		SP	567.7 558	0.0		A		0	

Sum [d] = 88.0 Sum [Kh x d] = 11.7

Source : "G" = Gradation, "P" = Permeability Test, "A" = Assumed

Kf = (sum [Kh x d]) / (sum [d]) = 0.133 fpm

EQUIVALENT BLANKET LENGTH (X3) (see note below)

(B-3)  $X3 = [(Kf \cdot d \cdot Zb) / (Kb)]^{0.5} = 373.6 \text{ ft.}$ 

Note: Depending on boundary conditions "X3" may be defined differently.

**MATHEMATICAL ANALYSIS OF UNDERSEEPAGE  
AND SUBSTRATUM PRESSURE**

15-APR-1991

From Appendix B of "EM 1110-2-1913" & "TM 3-424"

Note : The data from boring evaluation sheet " 73-1M " riverside  
and " 73-1M " Landside has been transferred to this spreadsheet.

Case 7, Semipervious Top Stratum Both Riverside and Landside.

Input from Boring Evaluation Sheet and cross-section.

Kf = 0.133 fpm of pervious substratum  
 Kbl = 0.0008 fpm  
 Kbr = 0.00016 fpm      Riverside cR =  $[(Kbr)/(Kf*Zbr*d)]^{.5}$   
 Zbl = 9.5 ft.      "c" cR = 0.00132  
 Zbr = 7.8 ft.      Landside cL =  $[(Kbl)/(Kf*Zbl*d)]^{.5}$   
 d = 88 ft.      "c" cL = 0.00268  
 L1 = 25 ft.  
 L2 = 131.2 ft.      (cR\*L1) = 0.0331      tanh(cRL1) = 0.03308  
 L3 = 1000 ft.      (cL\*L3) = 2.68235      tanh(cLL3) = 0.99069  
 Top of levee = 729.2  
 Flood elev. = 726.2      Uplift head = 20.2 ft.  
 Base of levee = 709.00      Seepage "H" = 17.2 ft.

Determine distance from Landside Levee Toe to Effective Seepage Exit, x3.

For L3 = infinity  
 (B-3)  $x3 = 1/cL = [(Kf*Zbl*d)/(Kbl)]^{.5}$   
       x3 = 372.8 ft.  
 For L3 = finite distance to a seepage block  
 (B-4)  $x3 = 1/(cL*tanh(cLL3))$   
       x3 = 376.3 ft.  
 For L3 = finite dist. to an open seepage exit.  
 (B-5)  $x3 = (tanh(cLL3))/cL$   
       x3 = 369.3 ft.

Determine distance from Effective Source Seepage Entry To Riverside Levee Toe, x1.

(B-7)  $x1 = (tanh(cRL1))/cR$       L1 is known and No seepage blocks or pits exist.  
       x1 = 25.0 ft.  
 (B-8)  $x1 = 1/(cR*tanh(cRL1))$       Seepage block exists.  
       x1 = 22831.1 ft.

Case 7.      d = 88      x1 = 25.0      L2 = 131.2      x3 = 372.8  
 Shape factor "S" =  $d/(x1+L2+x3)$  = 0.16635  
 Uplift Head = ho =  $H*(x3/(x1+L2+x3))$  = 14.2 ft  
 Input resisting soil wt. from Boring log sheet.  
 Wt. = 2817 psf = 45.1 ft. of water

45.1  
 Factor of Safety = ----- = 3.17      Min. F.S. > 1.5  
                          14.2      \*No Berm Required\*

Calculate seepage per ft of levee.      Check Uplift Gradient  
 Qs =  $(S)(Kf)(H)$       Io = ho/Zt      Zt = 45 ft.  
       = 0.381 ft<sup>3</sup>/min/ft.      Io = 0.32  
 Qs = 2.846 gpm/ft.

\*Berm Required\*  
 \*No Berm Required\*

*File for future use*

31 May 1973

CHASKA FLOOD CONTROL

SUMMARY

LIMITS AND MOISTURE CONTENTS

Request #73-11  
(NCS-SA-73-72-EDF)

Sample No. and Lab. No.	Depth (ft)	Moisture Content %	Limits	
			Liquid	Plastic
10/3Y-59	32.0-33.0	<u>Hole No. 73-1M</u> 17.5	14	14
3/3Y-67 6/3Y-68 12/3Y-69	6.5-7.0 18.0-18.5 38.0-38.5	<u>Hole No. 73-2M</u> 53.8 67.3 26.8	74 85 38	31 29 19
3/3Y-70 6/3Y-71 8/3Y-72 12/3Y-73	9.5-10.0 23.0-23.5 30.0-30.5 48.0-48.5	<u>Hole No. 73-3M</u> 65.3 26.9 25.0 22.6	82 38 27 21	30 17 21 21
9/3Y-81	37.0-39.5	<u>Hole No. 73-7M</u> 23.7	33	18
5/3Y-83	22.0-24.5	<u>Hole No. 73-9M</u> 25.7	38	16

N.C.D. LAB.

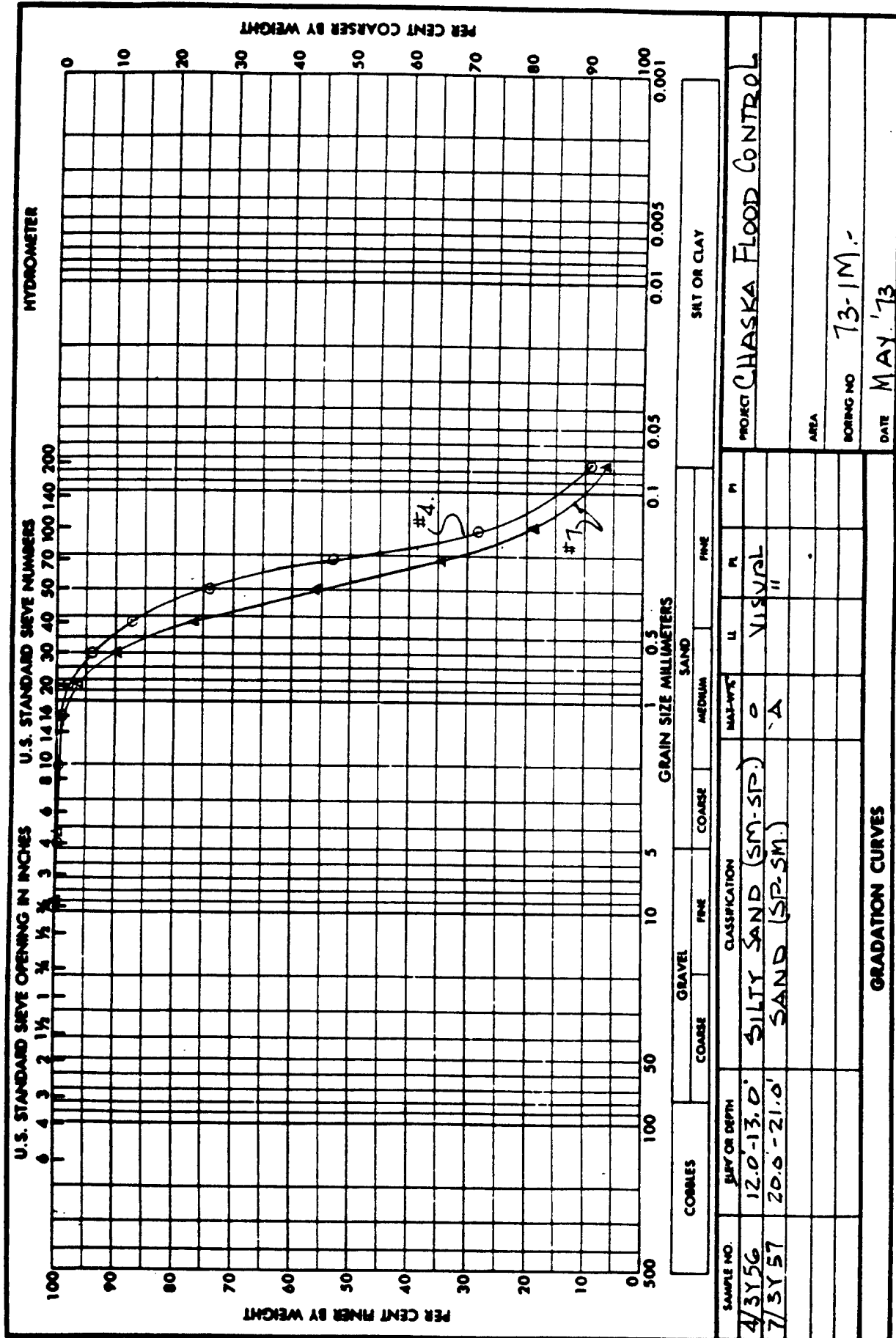
*encl 2*

**Project**

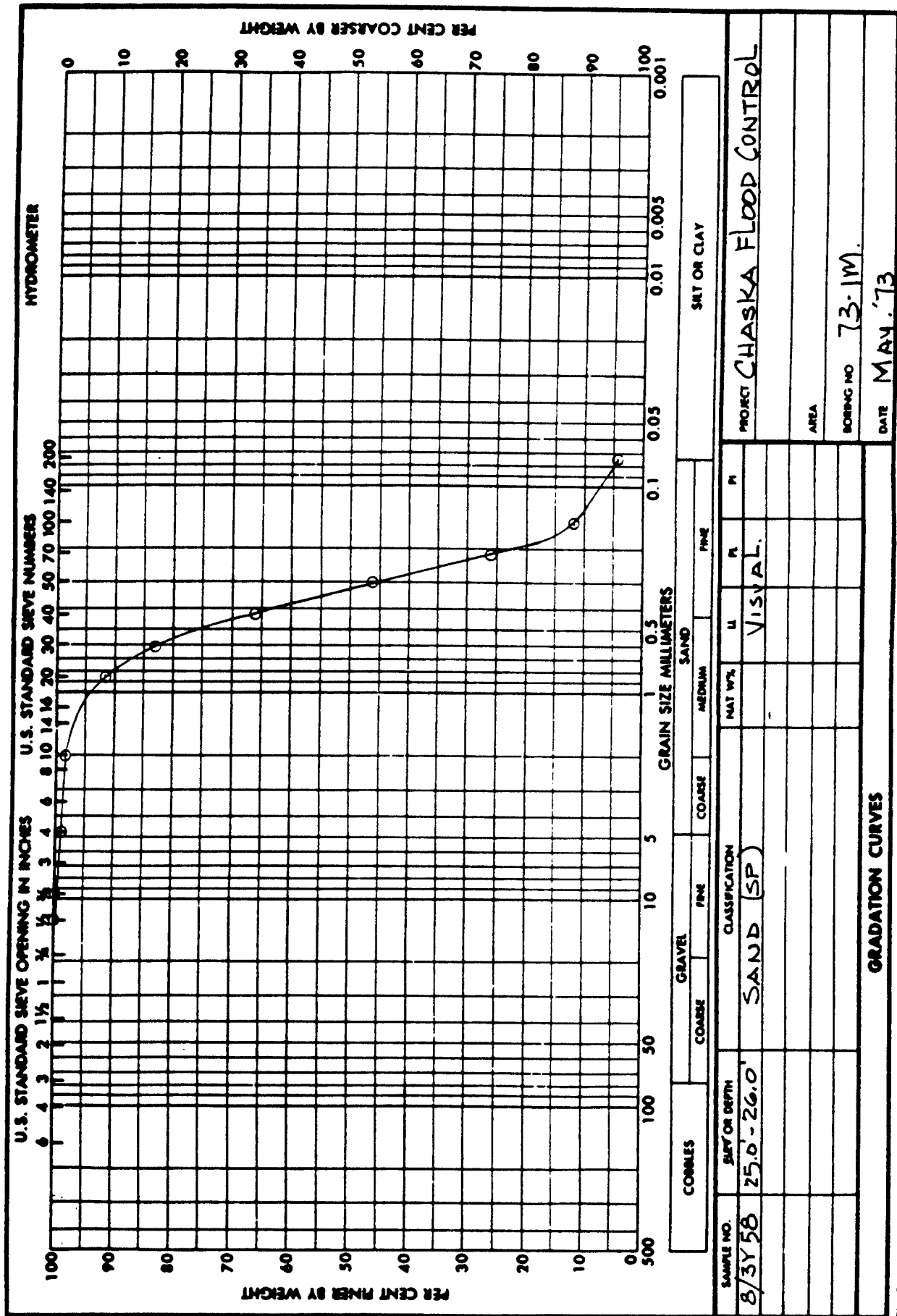
Chaska Flood Control

[illegible]

ECB FORM 24a  
70 SEP 68  
(Previous editions are obsolete)



**ENG FORM 2087** REPLACES WES FORM NO 1241, SEP 1962, WHICH IS OBSOLETE  
 1 MAY 63



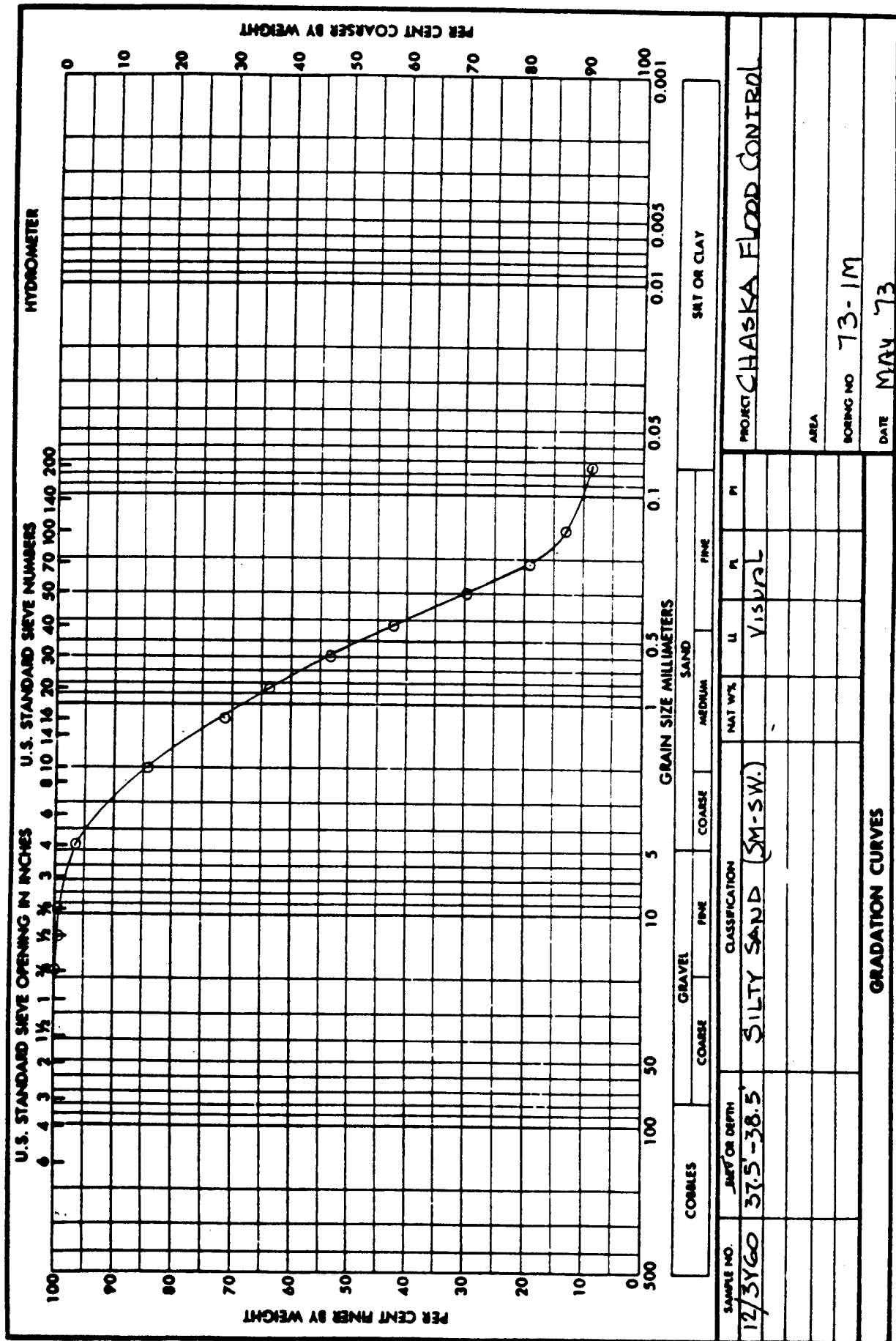
ENG FORM 2087

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

1 MAY 63

Figure C

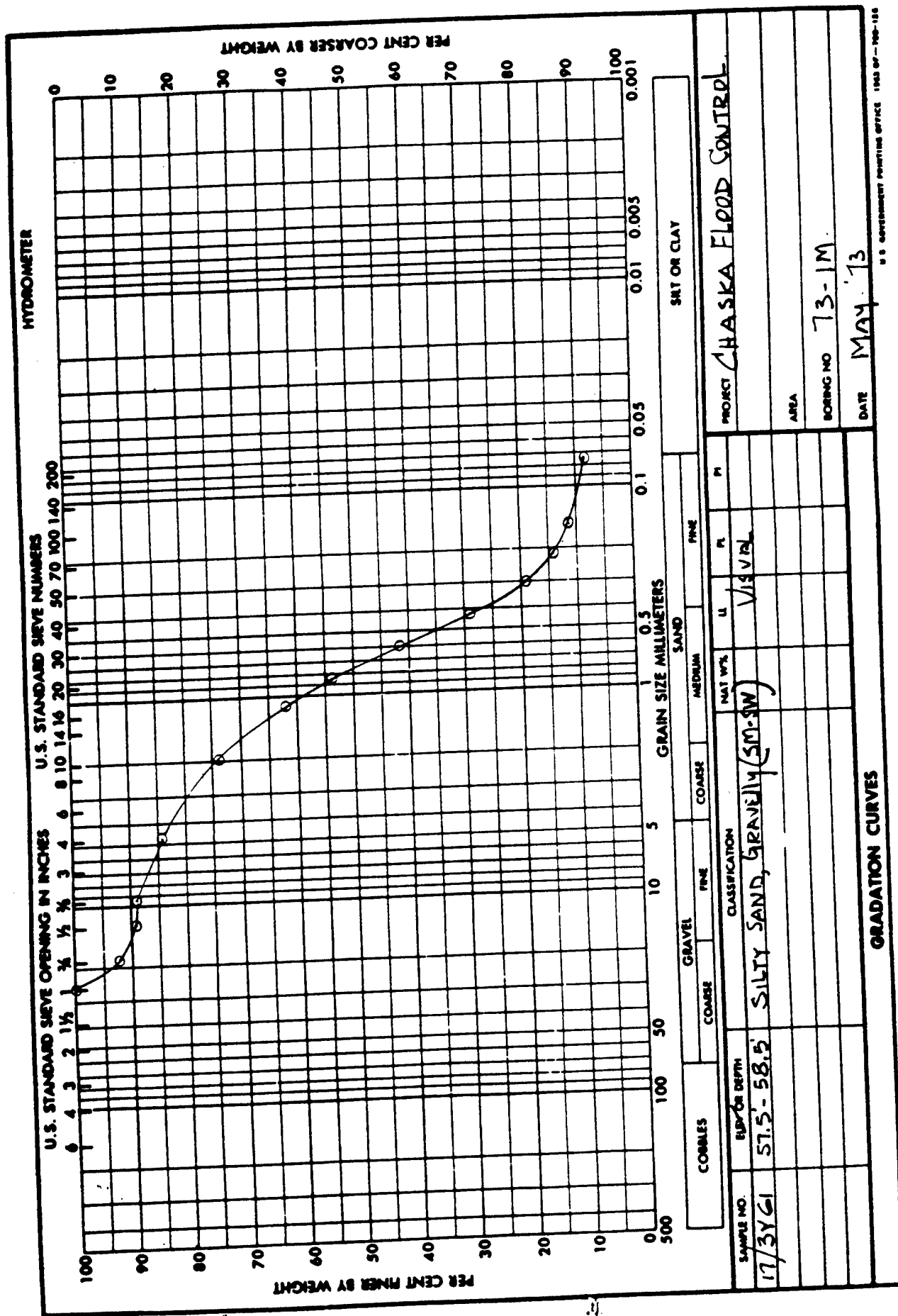




ENG FORM 2087 REPLACES WTS FORM NO. 1241, SEP 1942, WHICH IS OBSOLETE  
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Figure C-5



REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

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1 MAY 63

Figure C-1

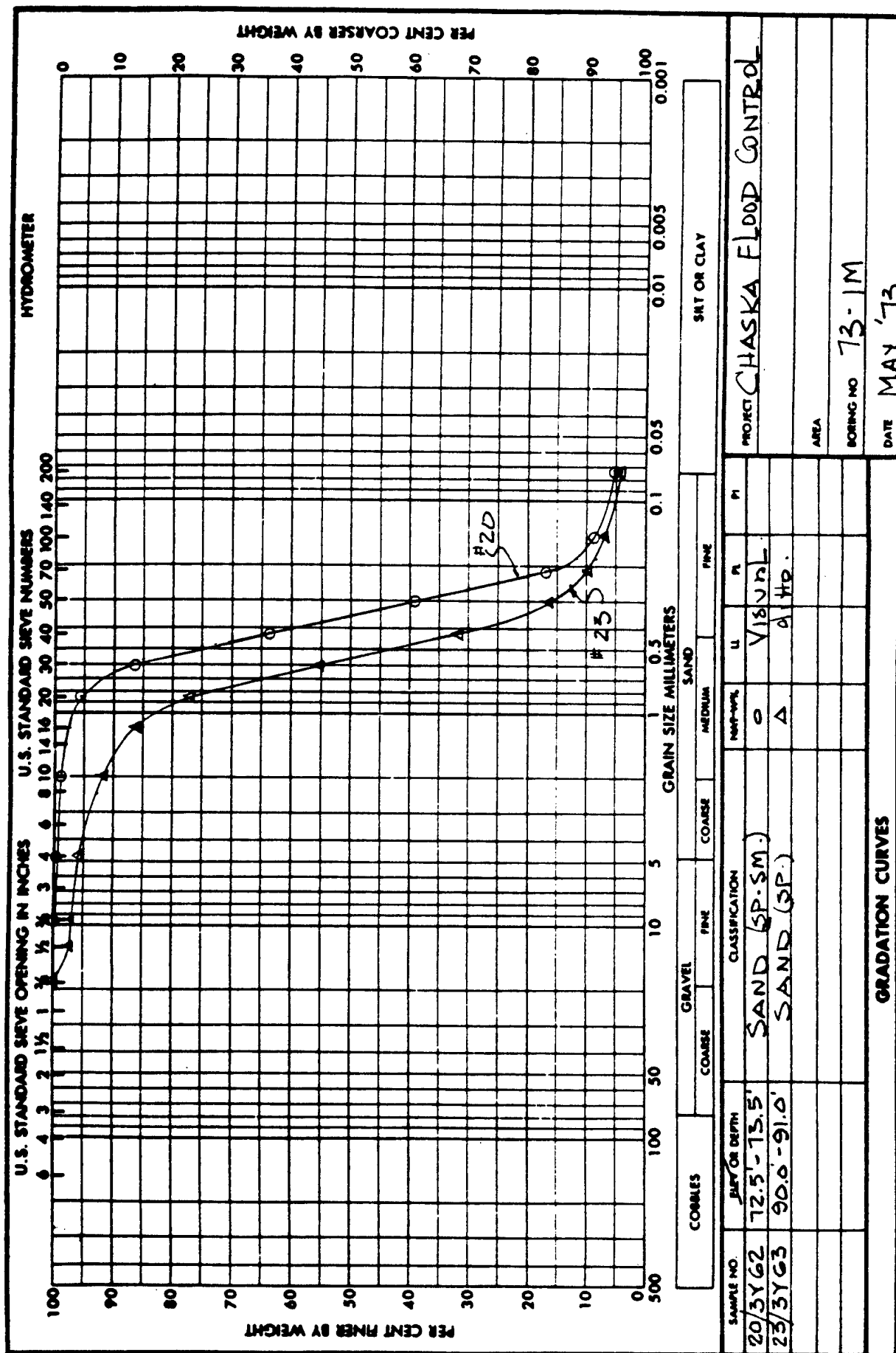
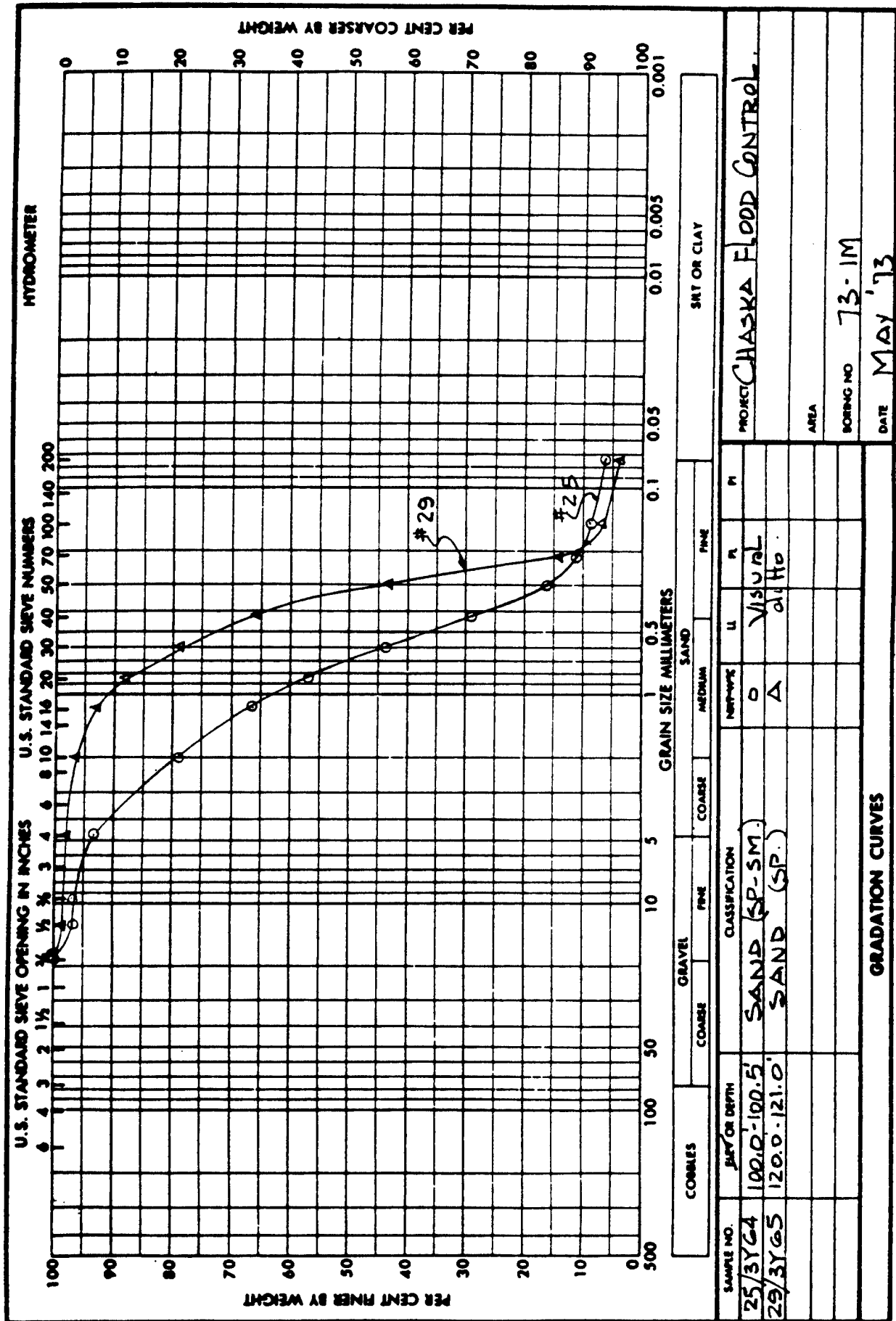
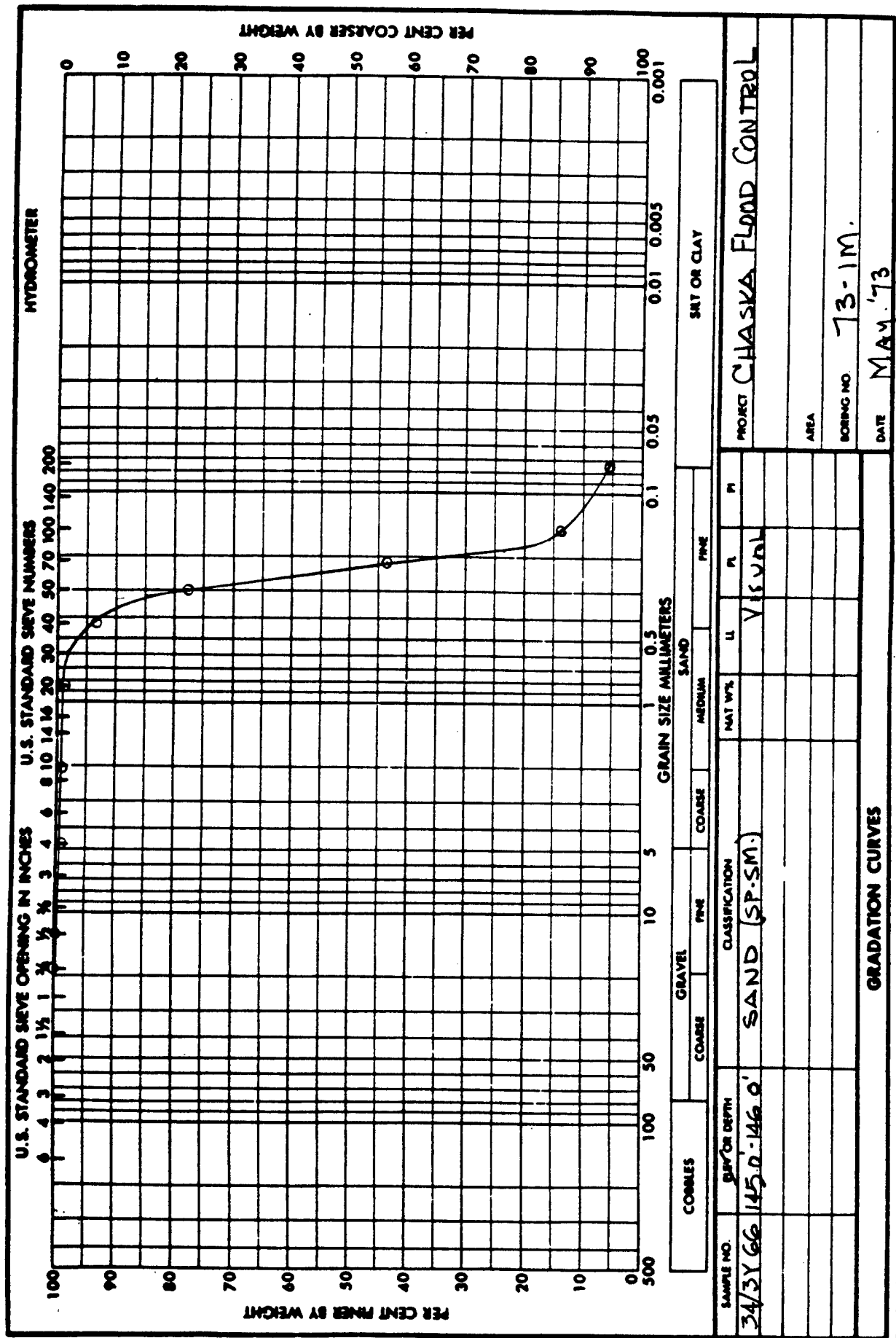
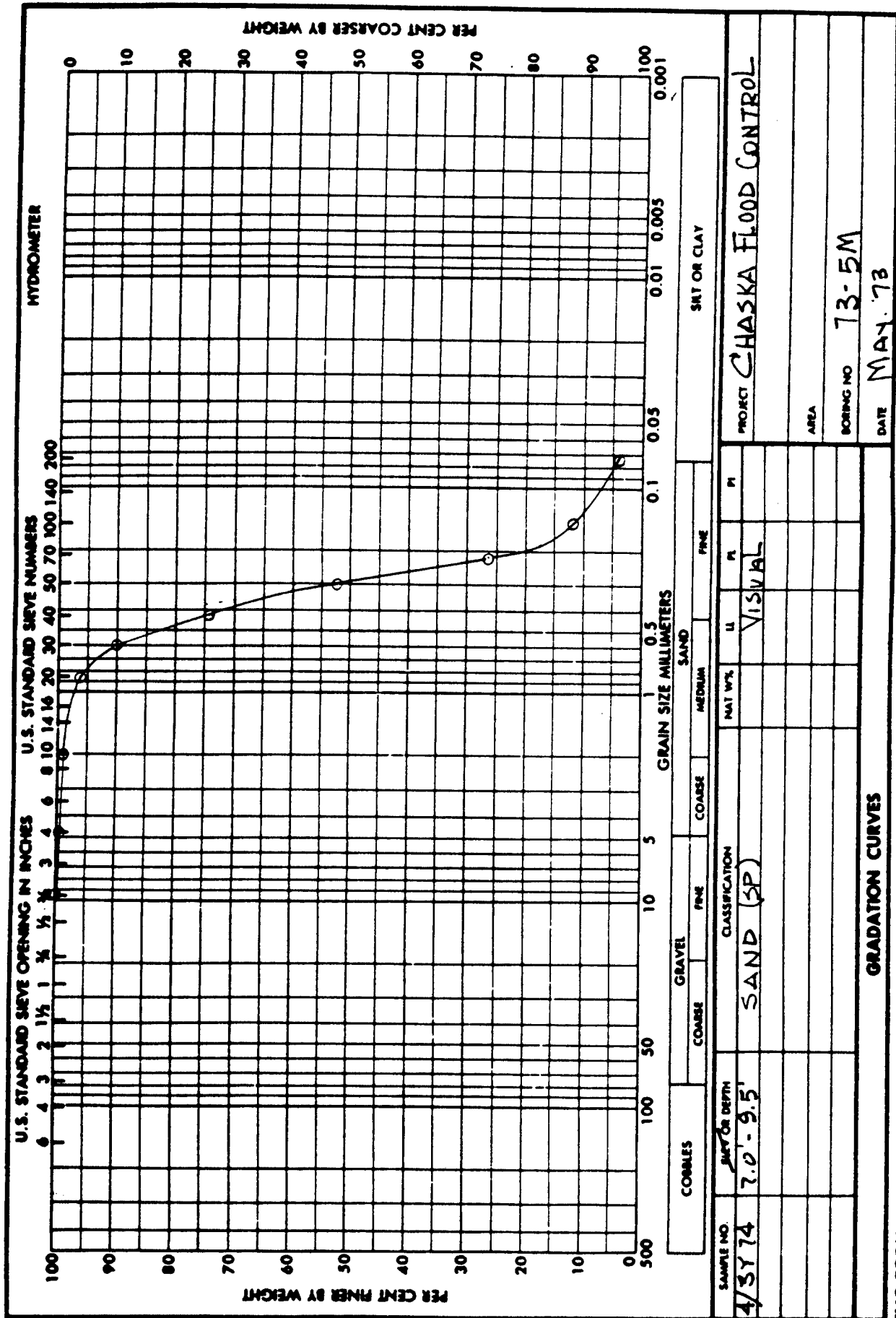


Figure C-7



ENG FORM 2087 REPLACES WES FORM NO 1241, SEP 1962, WHICH IS OBSOLETE  
1 MAY 63



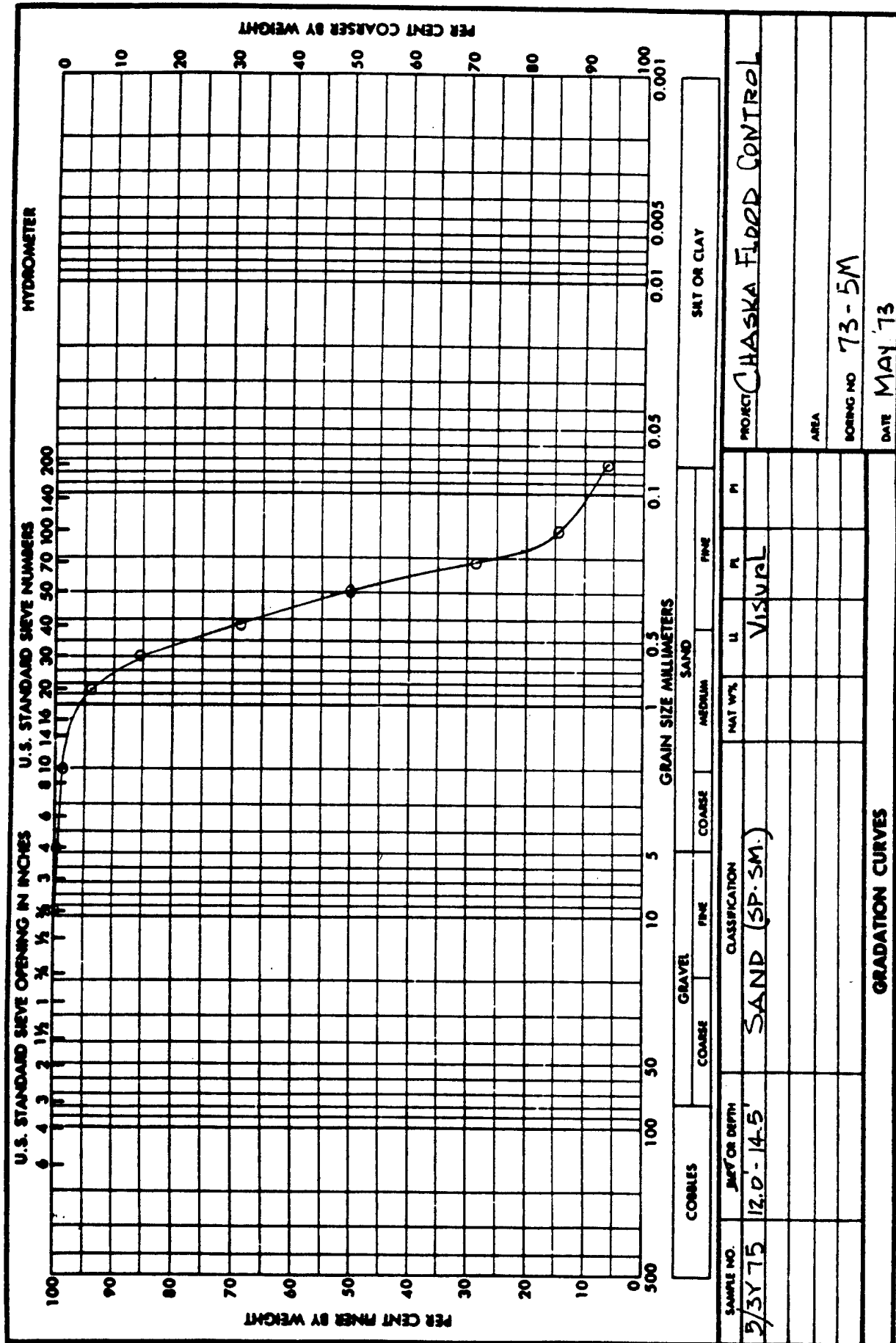


U.S. GOVERNMENT PRINTING OFFICE 1963 OF-740-110

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

ENG FORM 2087

Figure C-1



U.S. GOVERNMENT PRINTING OFFICE 1963 OF-700-106

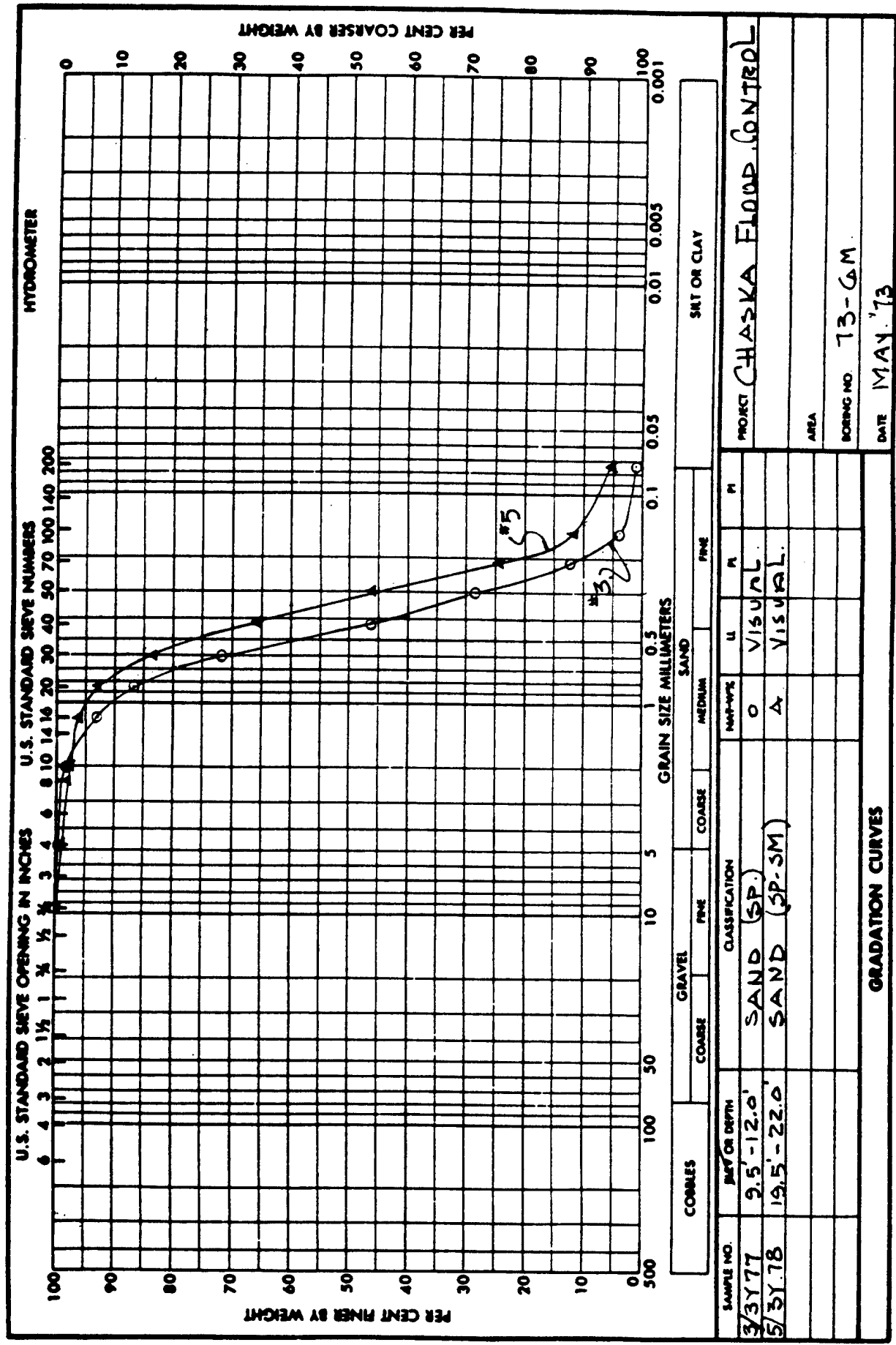
REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

ENG FORM 2087 1 MAY 63

Figure C-11







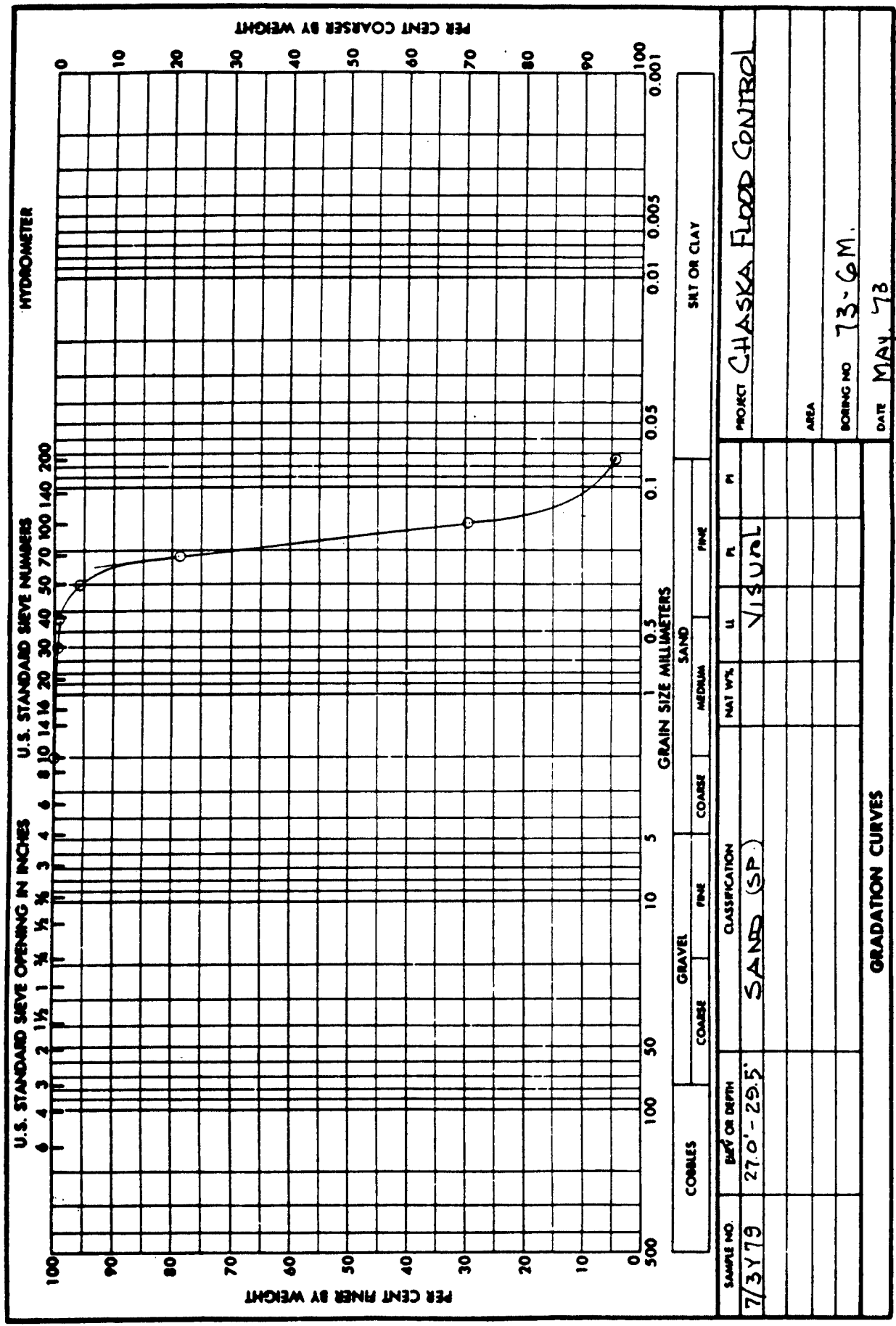
U.S. GOVERNMENT PRINTING OFFICE 1962 OF - 700-126

REPLACES WPS FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE.

ENG FORM 2087  
1 MAY 62

GRADATION CURVES

Figure C-13



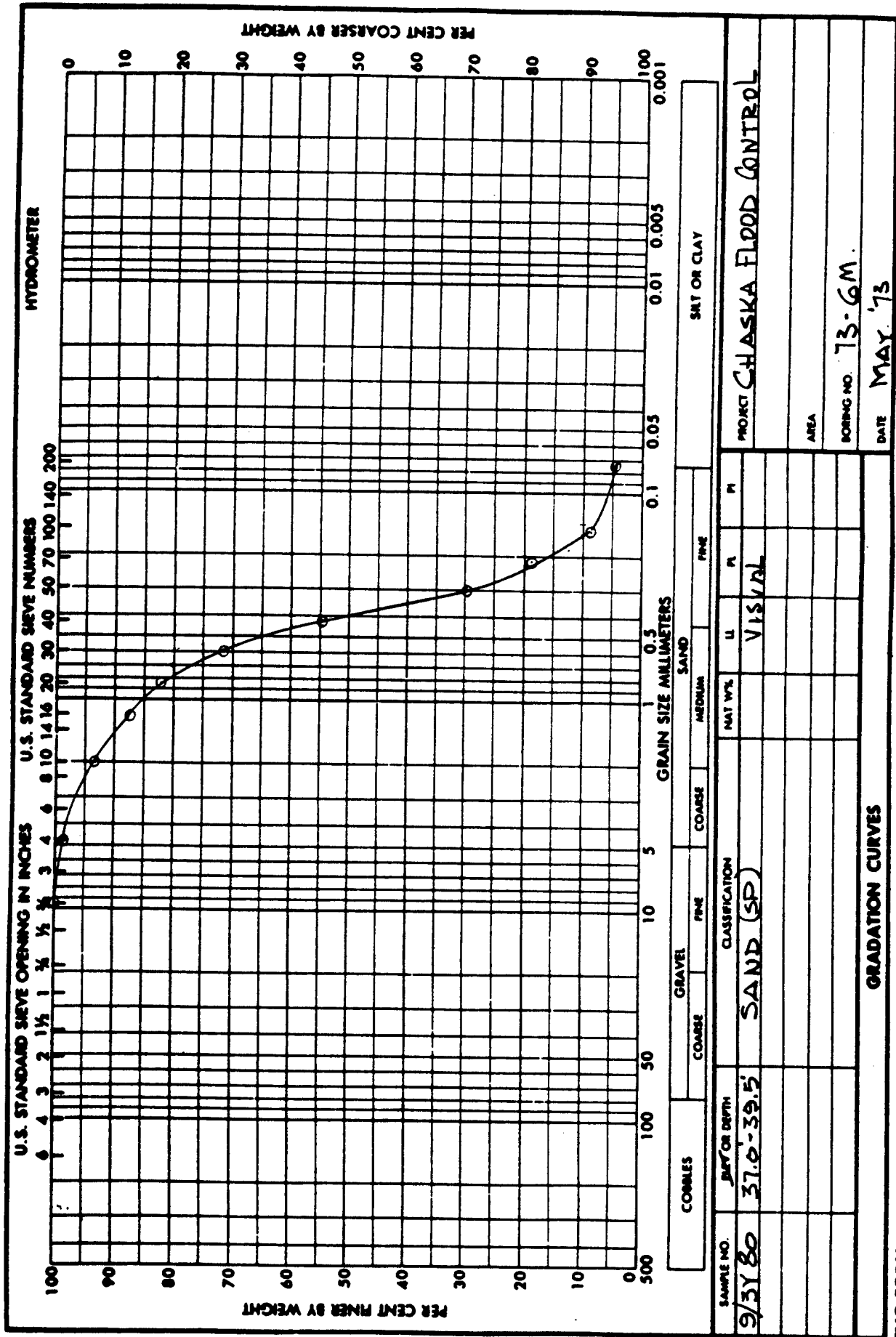
U.S. GOVERNMENT PRINTING OFFICE 1962 OF - 780-128

REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE

**ENG FORM 2087**

1 MAY 63

Figure C-14

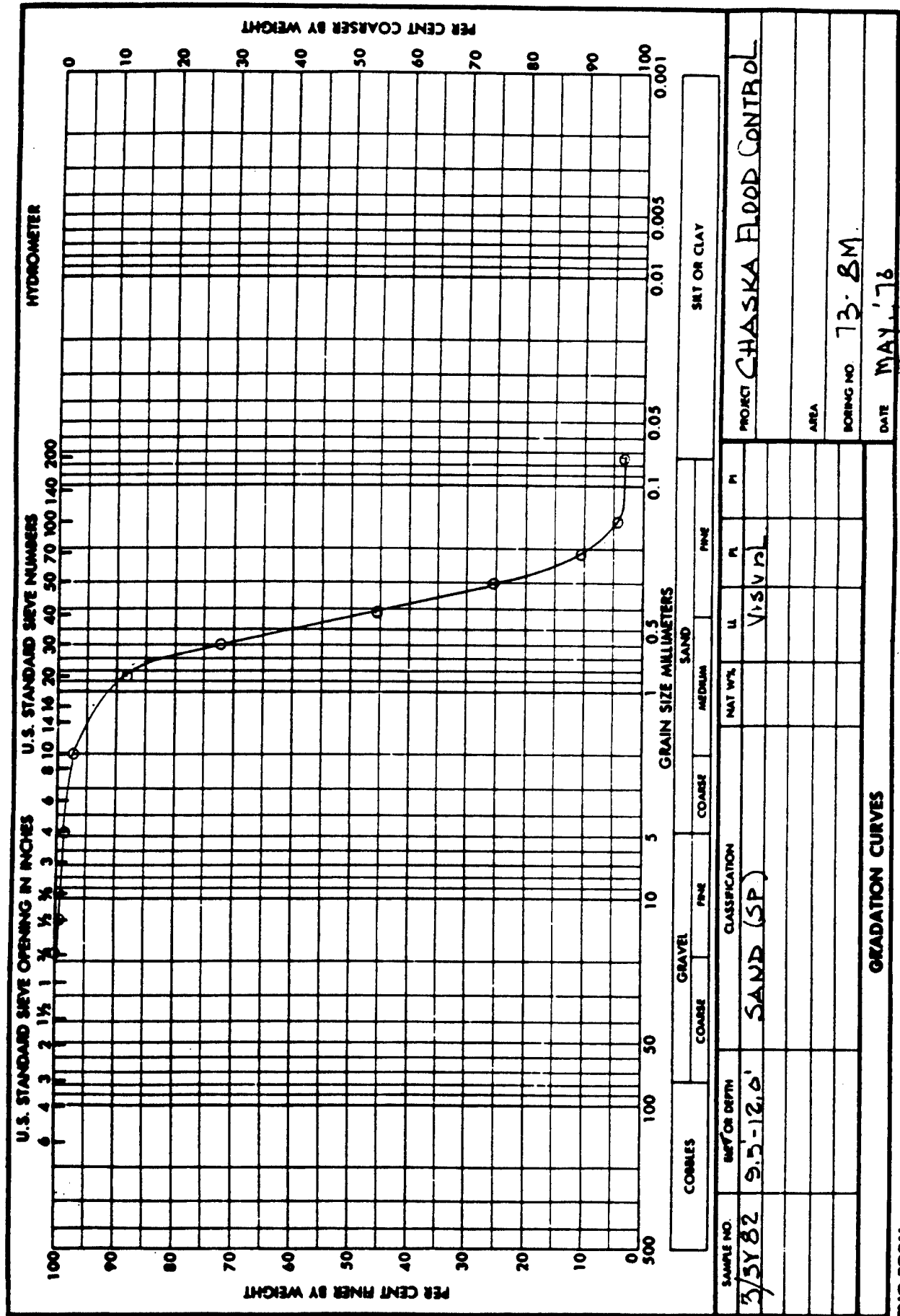


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1 MAY 63



ENG FORM 2087

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U.S. GOVERNMENT PRINTING OFFICE: 1963 OF - 700-126

Figure C-16

[illegible]

Table - 1

[illegible]

**MRD FORM 16 EDITION OF MAY 70 IS OBSOLETE**  
**NOV. 73**

# SOIL CLASSIFICATION RECORD SHEET

Project: Chaska, Minnesota Flood Control										Boring No: 79-18M through 79-20M										MRD Lab. No: 79/120									
Station: Range: Surf. Elev:										Depth To Water Table:										Bottom Of Hole:									
Sample No.	Depth To Bottom Of Sample	Moisture (%)	Plasticity (Att. Limits)		Grading (Cumulative Percents Finer)										Gradation Curve Analysis					Classification	Remarks								
			L.L.	P.I.	Hyd Analysis		U.S. Standard Sieve Sizes										D <sub>60</sub> (mm)	D <sub>30</sub> (mm)	C <sub>u</sub>			C <sub>c</sub>							
					Fines	200	80	40	20	10	4	3/8	3/4	1 1/2	3 in														
Hole 79-18M																													
2	4.0	12.7				25	42	69	75	78	84	88	94	100															
4	10.8					5	7	9	12	15	21	33	52	77	100														
7	21.9					8	17	67	82	85	87	91	93	100															
10	32.0					9	39	86	95	98	100																		
13	47.0					8	14	40	68	87	96	100																	
Hole 79-19M																													
2	6.0																												
4	12.5	21.4	28	12		13	21	48	66	80	89	94	98	100															
5	14.5																												
7	19.9					21	48	80	99	100																			
9	25.0	25.4	30	15		9	29	81	100																				
10	27.0	25.6	30	11																									
13	36.0	25.7	32	12																									
15	47.0	27.8	39	18																									
17	57.0					5	17	52	90	100																			
Hole 79-20M																													
1	2.0	21.3	36	17																									
2	5.5	16.8																											
3	6.5	17.0				8	23	79	96	100																			
5	12.0	16.1				64	87	98	100																				
7	19.0	17.4																											
9	25.0					26	67	94	99	100																			
12	32.0	20.7	37	19																									
15	42.0	20.1																											
16	47.0	23.6	43	26																									
18	55.0																												
						13	28	70	97	100																			

MRD FORM NOV. 75 16 EDITION OF MAY 70 IS OBSOLETE

Table - 3

Project:		Boring No:	MRD Lab. No:
Chaska, Minnesota Flood Control		79-21M and 79-22M	79/120
Station:	Range:	Surf. Elev:	Bottom Of Hole:

WARD FORM 16  
NOV. 75

Figure C-20



# SOIL CLASSIFICATION RECORD SHEET

Project: Chaska Minnesota - Flood Control Project										Boring No: 80-23M through 80-25M										MRD Lab. No: 80/227											
Station: Range: Surf. Elev: Bottom Of Hole:										Depth To Water Table:																					
Sample No.	Depth To Bottom Of Sample	Moisture (%)	Plasticity (At. Limits)		Grading (Cumulative Percents Finer)										Gradation Curve Analysis				Classification	Remarks	Pl.										
			L.L.	P.I.	Hyd Analysis				U.S. Standard Sieve Sizes						D <sub>60</sub> (mm)	D <sub>30</sub> (mm)	C <sub>u</sub>	C <sub>c</sub>													
					Fines		200		40		20		10		4		3/4		1 1/2		3 in										
					0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075		
Hole 80-23M	2	4.2																													
	3	6.0	14.8	35	21																										
	4	10.8	16.4																												
	5	12.1	3.5																												
	6	16.1	17.2	38	25																										
	8	20.3	26.7																												
	9	21.0	28.7																												
	10	22.3	16.8																												
	11	24.3	9.7																												
	12	26.5																													
	14	39.0																													
Hole 80-24M	2	4.3	21.8	19	4																										
	3	7.2	13.2																												
	4	11.0	15.4																												
	5	16.3	14.4	31	12																										
	6	17.5	21.7	45	27																										
	9	22.9	22.3	17	4																										
Hole 80-25M	5	6.9	10.2																												
	6	13.4																													
	9	21.5																													
	10	24.2	15.5																												
	12	31.7																													
	13	39.6																													
	14	41.9																													
	15	49.3	44.4																												
	16	51.1	23.3	38	25																										

Table - 1

MRD FORM NOV. 75 '66 EDITION OF MAY 70 IS OBSOLETE

# SOIL CLASSIFICATION RECORD SHEET

Project: Chaska Minnesota - Flood Control Project										Boring No: 80-28M					MRD Lab. No: 80/227																	
Station: -										Range: -					Depth To Water Table: -																	
Surf. Elev: -										Bottom Of Hole: -																						
Sample No.	Depth To Bottom Of Sample	Moisture (%)	Plasticity (Att. Limits)		Grading (Cumulative Percents Finer)										Gradation Curve Analysis					Classification	Remarks											
					U.S. Standard Sieve Sizes										D <sub>60</sub> (mm)	D <sub>30</sub> (mm)	D <sub>10</sub> (mm)	C <sub>u</sub>	C <sub>c</sub>													
					Fines		Hyd. Analysis		Gravel																							
			L.L.	P.L.	005	0075	20	40	60	80	100	200	4	10	20	40	60	80	100	3/8	1/2	3/4	1 1/2	3 in								
Hole 80-26H																																
2	3.6																															
3	6.0																															
4	14.2	17.7	52	37																												
5	15.9	21.3																														
7	21.6	26.9																														
8	26.3	39.4																														
9	27.3	30.4																														
11	29.9	27.9																														
13	31.1																															
14	41.3	24.6	21	4																												
Hole 80-27H																																
1	4.0	14.3																														
2	8.0	21.7	39	23																												
3	13.0	22.3	20	4																												
6	25.0																															
7	28.0	20.3																														
Hole 80-28M																																
2	6.1																															
3	9.2	19.1																														
5	11.9	41.7	43	22																												
6	14.2	30.5	41	21																												
8	19.2																															
9	21.5	28.0																														
10	27.4	23.9																														

Table - 2

MRD FORM NOV. 75 16 EDITION OF MAY 70 IS OBSOLETE

# SOIL CLASSIFICATION RECORD SHEET

[illegible]

Table - 1

NOV. 75 16 EDITION OF MAY 70 IS OBSOLETE

[illegible]

Table - 3

# SOIL CLASSIFICATION RECORD SHEET

Project: Chaaska Flood Control										Boring No: 83-52M through 83-57M		MRD Lab. No: 84/14											
Station: Range:										Surf. Elev:		Depth To Water Table:											
Sample No.	Depth To Bottom Of Sample	Moisture (%)	Plasticity (Att. Limits)		Grading (Cumulative Percent's Finer) U.S. Standard Sieve Sizes										Gradation Curve Analysis				Classification <i>Tech MEMO 3-357, May 67</i>	Remarks			
			L.L.	P.I.	Hyd Analysis		Sand				Gravel				D <sub>60</sub> (mm)	D <sub>30</sub> (mm)	D <sub>10</sub> (mm)	Cu			Cc		
					0.075	0.425	20	40	60	100	3/16	1/2	3/4										
Hole 83-52M																							
3	8.6					7	9	15	48	88	100						0.98	0.58	0.19	5.2	1.8		
7	16.5					5	30	92	100								0.28	0.18	0.088	3.2	1.3		
12	36.5	23.4	35	15																			
13	41.5	21.7	NP	NP		47	96	100														20	
Hole 83-53M																							
2	3.5	35.4	45	24																			
4	9.5	32.3	39	22																		21	
6	14.5	32.5	35	13																		17	
11	29.5	91.6	210	171																		22	
Hole 83-54M																							
1	1.5	7.5	31	13																			
3	11.5					18	69	99	100													Organic	
5	15.5					7	21	71	99	98	100						0.35	0.22	0.090	3.9	1.5		
Hole 83-55M																							
1	2.0																						
2	4.5					38	52	68	77	84	90	93	97	100									
5	14.5					43	84	90	93	95	97	100											
7	22.8					18	25	44	60	70	78	86	92	100									
						4	9	33	52	62	73	83	88	100			1.5	0.42	0.18	8.3	0.65		
Hole 83-56M																							
2	7.5	29.0	34	16																			
3	12.5					3	6	13	21	31	49	77	88	100			6.4	1.8	0.30	2.13	1.8		18
4	14.5					5	14	58	82	95	100						0.43	0.24	0.14	3.1	0.96		
Hole 83-57M																							
4	14.5																						
5	19.0					5	7	14	21	30	42	54	64	100			14.0	1.9	0.27	51.7	0.96		
						6	9	20	30	43	60	73	83	100			5.0	0.90	0.19	3.3	0.8		

Table - 1

# SOIL CLASSIFICATION RECORD SHEET

[illegible]

Table - 2

WARD FORM 16 EDITION OF MAY 70 IS OBSOLETE

# SOIL CLASSIFICATION RECORD SHEET

PROJECT: Chaska Flood Control - East Creek										BORING: 88-100M through 88-103M										HRD LAB NO. 88/177	
STATION:										DEPTH TO WATER TABLE:										BOTTOM OF HOLE:	
RANGE:										SURF. ELEV.:											
DEPTH		MOISTURE		PLASTICITY		HYD. ANALYSIS		GRADING (CUMULATIVE PERCENTS FINER)		GRAVEL		GRADATION CURVE ANALYSIS		CLASSIFICATION		REMARKS					
SAHF	NO. OF	TO	URE	LL	PI	FINES	0.075	0.075	20	40	60	100	3/8	3/4	1-1/2	3 IN	60	100	PL		
Hole 88-100M:																					
1	0.3																				
2	3.0	121.5	106	45																	
4	15.0																				
5	16.9																				
Hole 88-101M:																					
1	0.8	12.0	42	23																	
10	29.1	36.1	41	23																	
12	33.9	22.7	26	6																	
Hole 88-102M:																					
4	11.6	29.0	22	2																	
8	32.6	24.3	24	5																	
Hole 88-103M:																					
6	25.4																				
8	33.9	26.3	31	17																	
10	41.4	27.3	23	3																	
12	51.2	27.9	23	23																	

Note: Sample jars contained standing water. This has resulted in the moisture content of some samples being higher than the liquid limit.

TABLE 1

Figure C-27

[illegible]

TABLE 1



SOIL CLASSIFICATION RECORD SHEET

PROJECT: Chaska Flood Control Project - Minnesota River Levee (stage 4)										BORING: E9-116 through 89-116										MRD LAB NO. 90/135	
STATION:										DEPTH TO WATER TABLE:										BOTTOM OF HOLE:	
RANGE:										SURF. ELEV.:											
DEPTH	TO	MOISTURE	PLASTICITY	HYD. ANALYSIS	GRADING (CUMULATIVE PERCENTS FINER)	U.S. STANDARD SIEVE SIZE				GRAVEL				GRADATION CURVE ANALYSIS				CLASSIFICATION		REMARKS	
SAMP. NO.	BOTTOM	NO. OF SAMP.	LL	PI	FINES	200	20	40	60	100	20	40	60	100	20	40	60	100	TECH MEMO 3-357, MAY 67	PL	
Hole: 89-114																					
2	5.2					3	14	65	92	98	99	100			0.35	0.23	0.13	2.80	1.21		
4	19.5					7	42	86	94	97	99	100			0.23	0.12	0.07	3.29	0.89		
5	24.5					5	15	53	76	91	97	99	100		0.50	0.24	0.12	4.17	0.96		
6	29.0					6	21	90	99	100					0.25	0.20	0.10	2.75	1.44		
7	34.0					7	15	56	88	97	99	100			0.45	0.24	0.11	4.09	1.16		
8	33.9					10	28	67	99	100					0.24	0.14	0.08	3.00	1.05		
9	44.0					8	11	41	61	76	87	96	100		0.80	0.29	0.11	7.27	0.96		
11	54.5					7	11	24	53	78	87	97	100		0.89	0.35	0.16	5.56	0.86		
14	65.7					6	26	80	90	96	99	100			0.25	0.18	0.09	2.73	1.44		
15	59.5					11	16	38	60	77	88	97	100		0.82	0.30	0.04	20.50	2.74		
16	73.2					10	11	26	43	64	80	92			1.80	0.46	0.09	20.00	1.31		
Hole: 89-115																					
1	3.7					19	27	56	74	81	85	91	100								
3	11.5					6	23	69	96	99	100				0.37	0.20	0.09	4.11	1.20		
4	17.5					8	22	70	88	96	98	100			0.35	0.20	0.09	3.89	1.27		
5	19.0					7	13	96	93	96	99	100			0.50	0.27	0.09	5.88	1.72		
6	24.1	19.2	25	7																	
7	29.0					6	35	94	99	100					0.24	0.16	0.09	2.52	1.25		
8	34.0					7	13	40	75	90	96	99	100		0.60	0.36	0.13	4.62	1.66		
9	39.0					4	29	96	100						0.25	0.17	0.09	2.73	1.31		
12	54.0					8	12	31	52	73	84	96	100		1.10	0.39	0.12	9.17	1.15		
15	59.5					6	19	29	58	73	83	95	100		0.90	0.43	0.16	5.63	1.28		
Hole: 89-116																					
1	3.5					24	61	98	99	100											
2	10.0					13	20	32	41	54	67	80	90	100							
3	15.0					22	30	57	78	89	96	100									
5	22.0					4	13	67	89	95	97	99	100		0.35	0.23	0.15	2.33	1.01		
7	34.5					7	15	60	87	96	98	100			0.40	0.25	0.10	4.00	1.56		
8	40.0					9	49	98	99	100					0.20	0.12	0.08	2.56	0.92		
9	44.0					7	11	30	79	94	98	100			0.52	0.40	0.16	3.25	1.92		
11	48.6					5	10	86	94	97	99	100			0.28	0.24	0.13	1.56	1.14		
12	50.0	18.5	17	2											0.51	0.24	0.09	6.00	1.33		
14	55.0					9	17	50	73	85	93	100			0.53	0.32	0.12	4.42	1.61		
16	62.2					19	68	92	98	100											
17	64.5					8	14	42	69	84	93	98	100								
18	70.0					15	41	91	97	99	99	100									

TABLE 2

Figure C-29

PROJECT: Chaska Flood Control Project - Minnesota River Levee (Stage 4)										BORING: 99-117a				MRD LAB NO. 90/135											
STATION:										RANGE:				SURF. ELEV.:				DEPTH TO WATER TABLE:				BOTTOM OF HOLE:			
DEPTH TO		MOISTURE		PLASTICITY		HYD. ANALYSIS		GRADING (CUMULATIVE PERCENTS FINER)				GRADATION CURVE ANALYSIS				CLASSIFICATION		REMARKS		PL					
SAMP. BOTTOM		URE		LIMITS		FINES		U.S. STANDARD SIEVE SIZE				D60 : D30 : D10				TECH MEMO 3-357, MAY 67:									
NO. OF SAMP.		(%)		LL : PI		0.005 : 0.02mm		SANDS				(mm) : (mm) : (mm)				Cc									
								30 : 60 : 20 : 10 : 4				3/8 : 3/4 : 1-1/2 : 3 IN													
Note: 99-117																									
1		0.7		20.8		34		11														23			
2		1.4				21		28														53			
3		4.0																							
4		19.0		15.9				9				11		27		31		45		56		75			
5		24.9		25.3		24		6																Slight elasticity	
								Test in test.																	

TABLE 3

SOIL CLASSIFICATION RECORD SHEET

PROJECT: Chaska Flood Control Project - Minnesota River Levee										BORING: 89-112a through 89-119a										MRD LAB NO. 90/135	
STATION:										DEPTH TO WATER TABLE:										BOTTOM OF HOLE:	
RANGE:										SURF. ELEV.:											
DEPTH TO SAMP. NO.	MOIST. USE (%)	PLASTICITY (ATT. LIMITS)	HYD. ANALYSIS (FINES)	GRADING (CUMULATIVE PERCENTS FINER)	SANDS	GRAVEL	GRADATION CURVE ANALYSIS	CLASSIFICATION	REMARKS	PL											
Hole 89-118:																					
1	1.6	9.2	21	8																	
2	4.0	8.8	21	4																	
3	9.5																				
4	14.5																				
5	18.6																				
6	19.4																				
7	24.5																				
8	29.0																				
9	39.5																				
10	44.0																				
11	54.0																				
12	62.2	19.1	29	3																	
13	74.0																				
14	84.0																				
15	94.0																				
16	104.5																				
17	114.0																				
18	121.8																				
19	124.9																				
20	128.0	22.0	23	1																	
21	130.0																				
22	134.5																				
23	139.5																				
24	144.5																				
25	149.0																				
26	151.5	22.3	31	15																	
27	152.0																				
28																					
29																					
30																					
31																					
32																					
33																					
34																					
35																					
36																					
37																					
38																					
39																					
Hole 89-119:																					
10	44.0	24.0	37	21																	

TABLE 1

Figure C-31

SOIL CLASSIFICATION RECORD SHEET

PROJECT: Chaska Flood Control Project - Minnesota River Levee										BORING: 89-121a through 89-123a										MRD LAB NO. 90/135																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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ELEV.:										DEPTH TO WATER TABLE:										BOTTOM OF HOLE:																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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67										PL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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TABLE 2

Figure C-32

SOIL CLASSIFICATION RECORD SHEET

PROJECT: Alaska Flood Control Project - Minnesota River Levee										BORING: 89-124		MRD LAB NO. 90/135						
STATION: RANGE:										SURF. ELEV.:		DEPTH TO WATER TABLE:		BOTTOM OF HOLE:				
SAMP NO.	TOF SAMP	MOISTURE (%)	PLASTICITY INDEX (PI)	HYD ANALYSIS FINES	GRADING (CUMULATIVE PERCENTS FINER)					GRADATION CURVE ANALYSIS					CLASSIFICATION	REMARKS	PL	
					80	60	40	20	10	5	3/8	3/16	1-1/2	3 IN				D60 (mm)
Hole 89-124																		
1	1.7				53	72	90	93	100									
3	9.5				4	10	71	98	100									
5	16.2				43	78	97	100										
6	19.5				4	9	46	76	94	93	100							
8	29.0				7	31	95	98	100									
13	36.0				6	12	36	70	88	97	100							
11	40.0				6	15	62	83	92	96	100							
12	44.5				7	10	13	34	56	79	96	100						
13	49.5				10	17	48	83	96	100								
14	64.5				10	15	34	56	76	93	96	100						
19	76.5				7	12	40	73	86	94	99	100						
20	80.0				15	22	39	58	75	88	97	100						
21	84.0				7	11	30	53	76	85	91	95	100					
22	85.0				69	74	84	93	97	100								
25	99.5				13	25	43	59	70	79	88	98	100					
26	105.0				7	21	92	100										
27	109.0				9	20	69	98	95	100								
23	114.5				9	26	74	97	100									
29	115.0				27	75	98	100										
30	115.7				8	29	42	66	87	98	100							
31	120.0				10	20	65	86	97	99	100							
32	121.5				12	24	89	98	100									
33	122.8	26.5			10	21	55	88	97	98	100							
34	130.0																	

Figure C-33

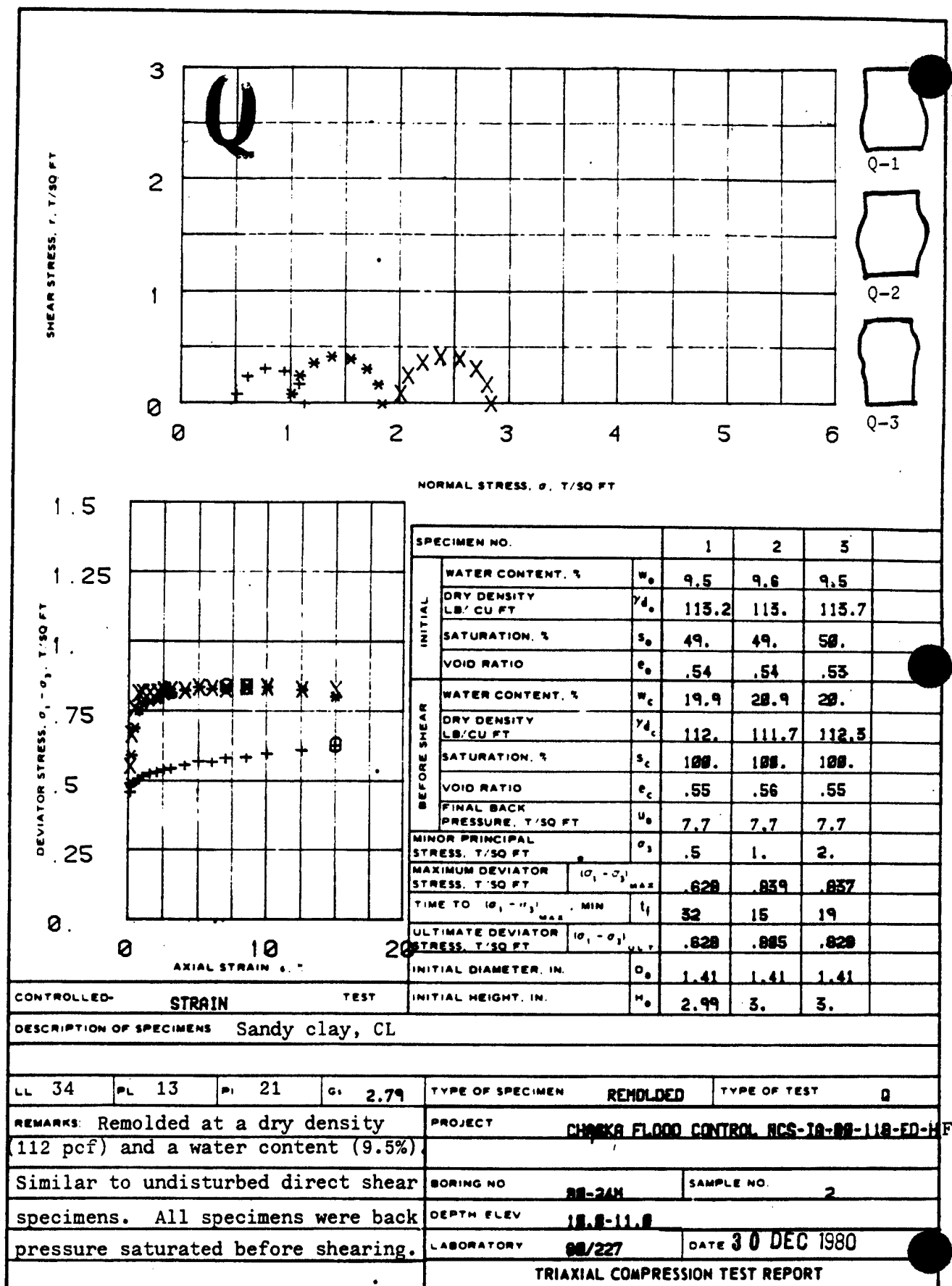
SOIL CLASSIFICATION RECORD SHEET

PROJECT: Chaska Flood Control Project										BORING: 89-125a, 89-126au, 89-126m and 89-130a										MRD LAB NO. 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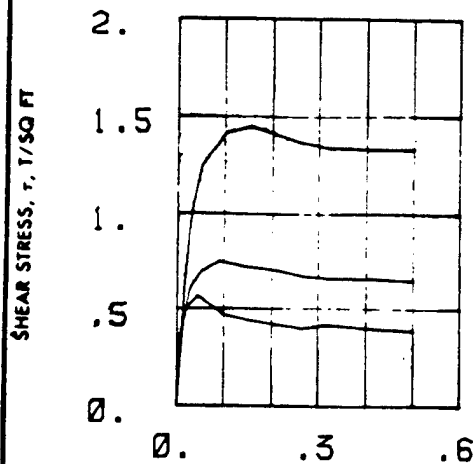
# SOIL CLASSIFICATION RECORD SHEET

PROJECT: Chaska Flood Control Project, Minnesota River Levee (Stage 4)										BORING: 89-113M 1-5, 114M 1, 123M 20-22, 124M 18-23-24										MRD LAB NO. 90/135																																																																																																																																																																																																							
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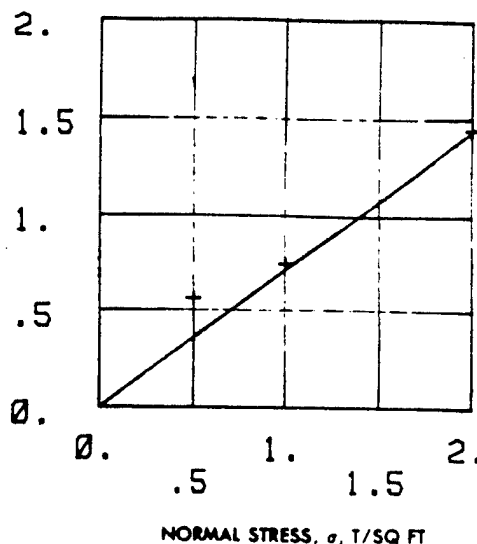
TABLE 1



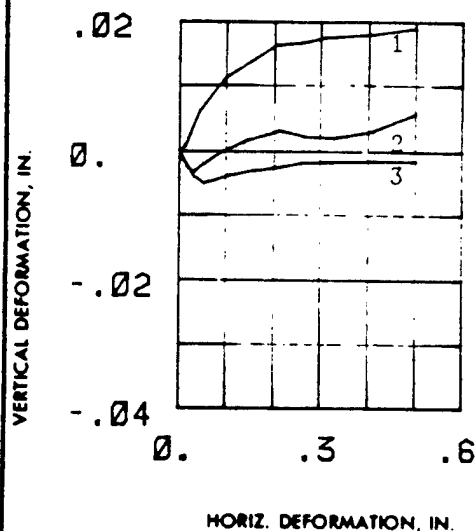




SHEAR STRESS,  $\tau$ , T/SQ FT



SHEAR STRENGTH,  $s$ , T/SQ FT



VERTICAL DEFORMATION, IN.

### SHEAR STRENGTH PARAMETERS

$$\phi = 35.9^\circ$$

$$\tan \phi = 0.725$$

$$c = \text{---} \text{ T/SQ FT}$$

**S**

- ☐ CONTROLLED STRESS
- ☒ CONTROLLED STRAIN

TEST NO.			1	2	3	
INITIAL	WATER CONTENT	$w_o$	9.9 %	8. %	8.7 %	%
	VOID RATIO	$e_o$	.49	.5	.51	
	SATURATION	$S_o$	56. %	45. %	47. %	%
	DRY DENSITY, LB/CU FT	$\gamma_d$	116.8	116.3	115.1	
VOID RATIO AFTER CONSOLIDATION		$e_c$	.5	.49	.48	
TIME FOR 50 PERCENT CONSOLIDATION, MIN		$t_{50}$				
FINAL	WATER CONTENT	$w_f$	17. %	15. %	15.2 %	%
	VOID RATIO	$e_f$	.51	.49	.48	
	SATURATION	$S_f$	94. %	86. %	88. %	%
NORMAL STRESS, T/SQ FT		$\sigma$	.5	1.	2.	
MAXIMUM SHEAR STRESS, T/SQ FT		$\tau_{max}$	.57	.75	1.45	
ACTUAL TIME TO FAILURE, MIN		$t_f$	180	300	450	
RATE OF STRAIN, IN./MIN X .8881			2.44	2.93	3.4	
ULTIMATE SHEAR STRESS, T/SQ FT		$\tau_{ult}$	.4	.65	1.33	

TYPE OF SPECIMEN **UNDISTURBED** **3. IN. SQUARE** **1.81 IN. THICK**

CLASSIFICATION **Sandy clay, CL**

LL **34** PL **13** PI **21** G. **2.79**

REMARKS **Brown, brittle, hard consistency, medium strength at PL, . gloss shine, slow shake reaction, surficial cracks, highly calcareous**

PROJECT **CHASKA FLOOD CONTROL NCS-1A-88-118-ED-HF**

AREA **MRD LAB 40: 88/227**

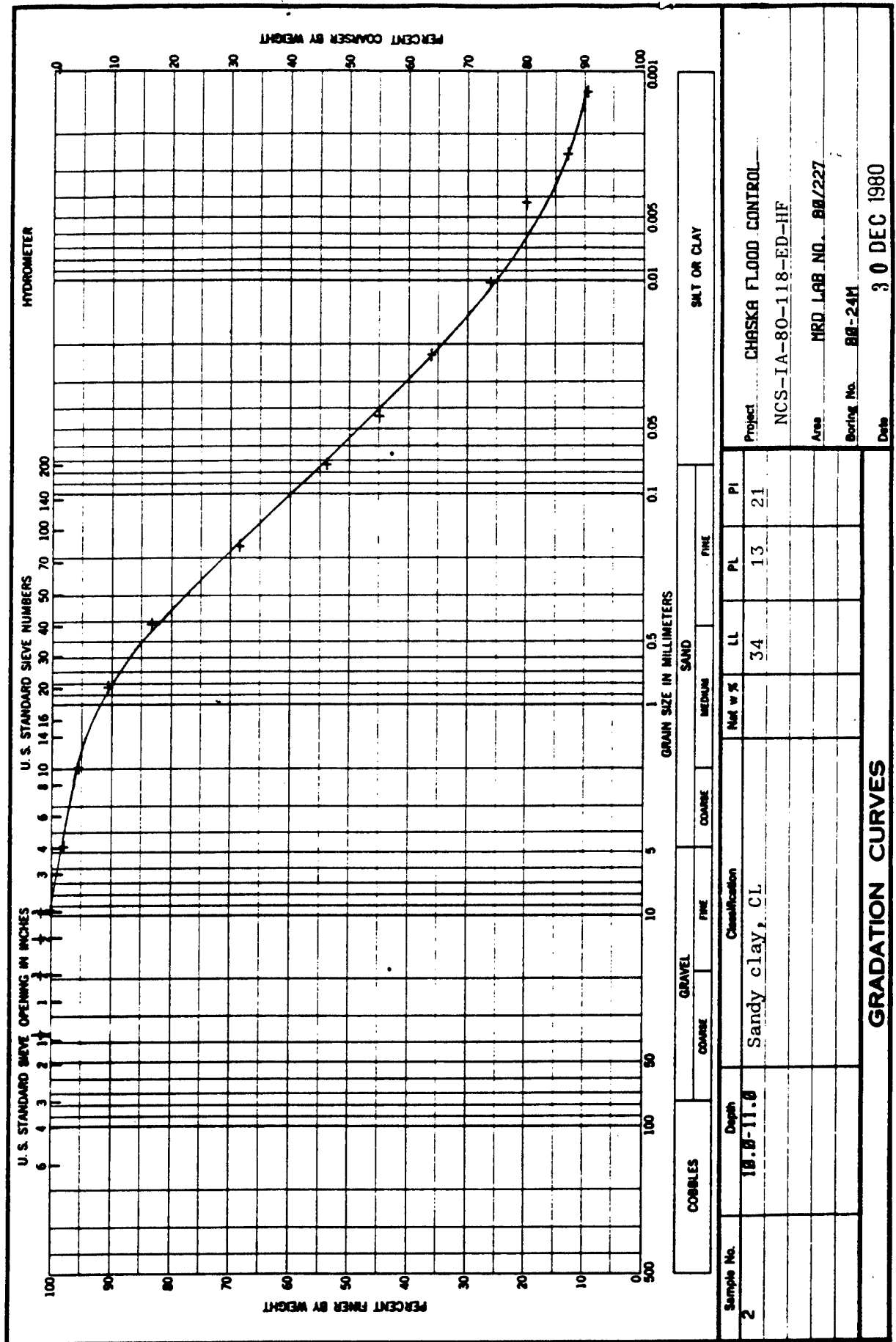
BORING NO. **88-24H**

SAMPLE NO. **2**

DEPTH **18.8-11.1**

DATE **30 DEC 1980**

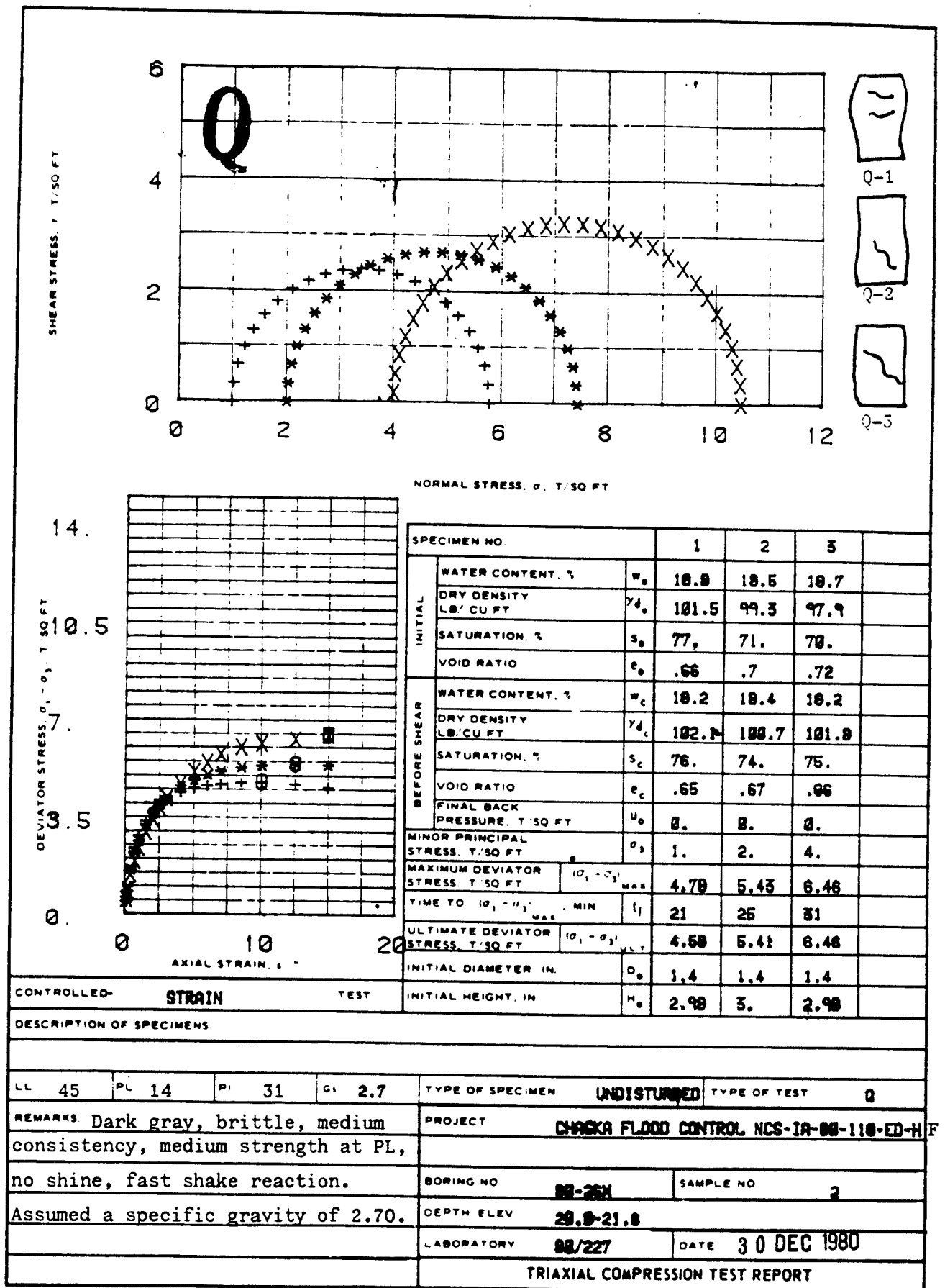
**DIRECT SHEAR TEST REPORT** Figure C-37

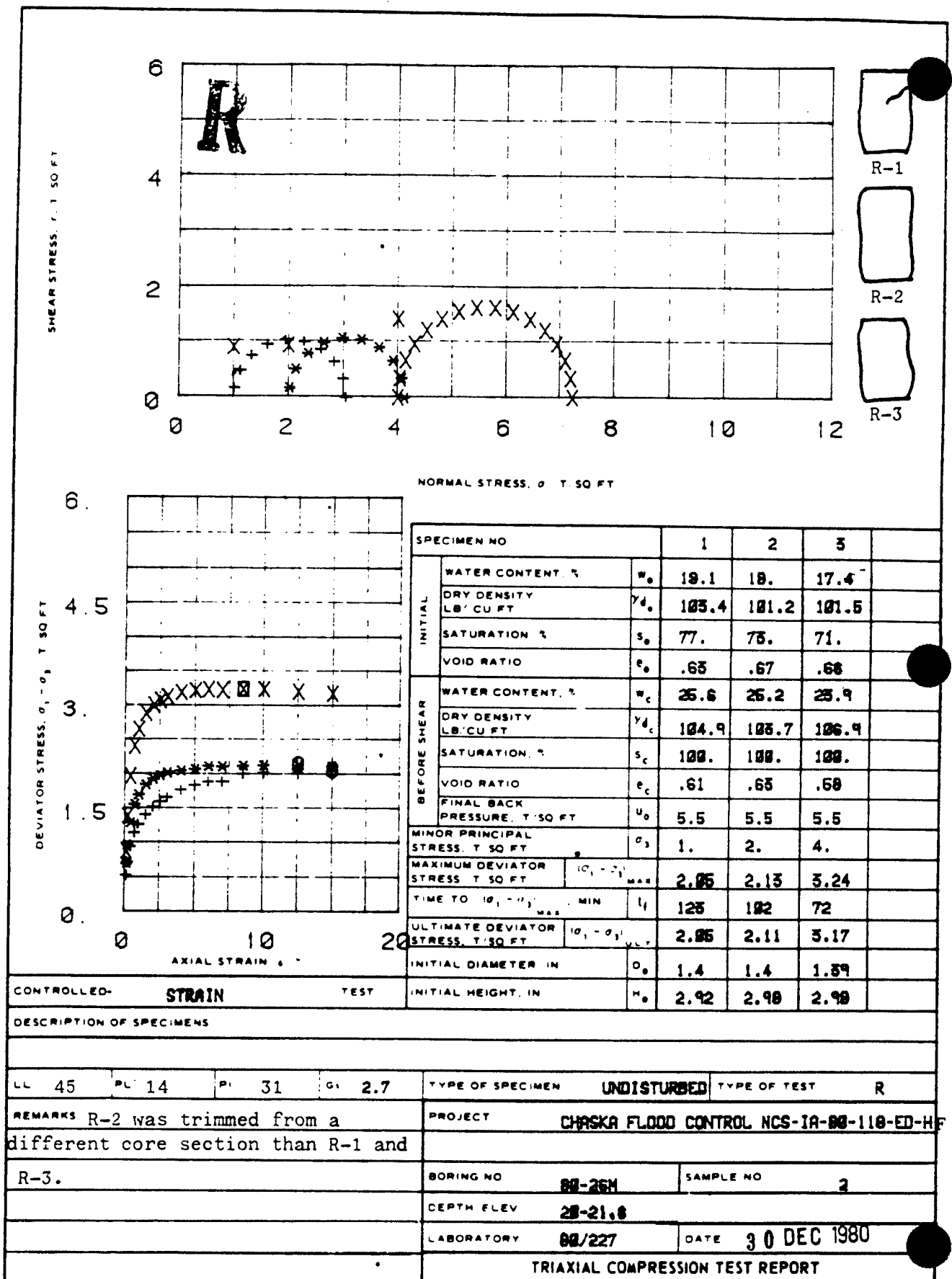


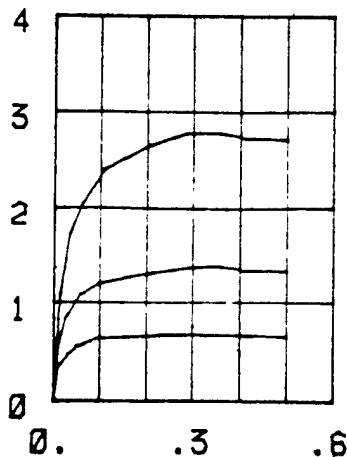
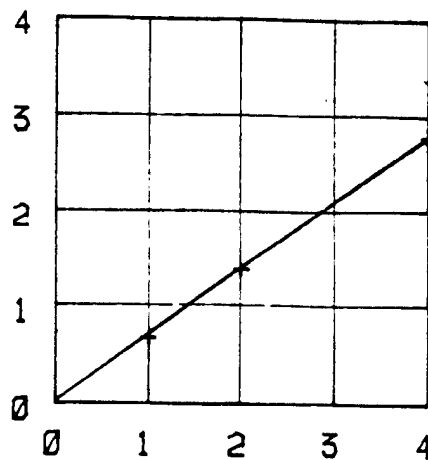
ENG FORM 2087  
 MAY 68

FIG 3

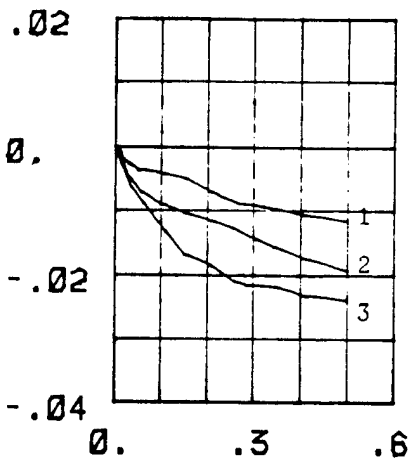
Figure C-38





SHEAR STRESS,  $\tau$ , T/SQ FTSHEAR STRESS,  $\tau$ , T/SQ FTNORMAL STRESS,  $\sigma$ , T/SQ FT

VERTICAL DEFORMATION, IN.



HORIZ. DEFORMATION, IN.

SHEAR STRENGTH PARAMETERS

$$\phi = 34.9^\circ$$

$$\tan \phi = 0.698$$

$$c = \text{---} \text{ T/SQ FT}$$

- ☐ CONTROLLED STRESS  
☒ CONTROLLED STRAIN

TEST NO.		1	2	3	
INITIAL	WATER CONTENT	w.	14.5 %	14.5 %	15.7 %
	VOID RATIO	e.	.85	.81	.76
	SATURATION	S.	46. %	40. %	56. %
	DRY DENSITY, LB/CU FT	$\gamma_d$	91.1	92.9	96.
VOID RATIO AFTER CONSOLIDATION		e.	.82	.81	.65
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t <sub>50</sub>			
FINAL	WATER CONTENT	w <sub>f</sub>	29.2 %	27.8 %	22.2 %
	VOID RATIO	e <sub>f</sub>	.79	.75	.57
	SATURATION	S <sub>f</sub>	100 %	100 %	100. %
NORMAL STRESS, T/SQ FT		$\sigma$	1.	2.	4.
MAXIMUM SHEAR STRESS, T/SQ FT		$\tau_{max}$	.68	1.39	2.79
ACTUAL TIME TO FAILURE, MIN		t <sub>f</sub>	630	990	690
RATE OF STRAIN, IN./MIN X .0001			3.63	3.46	4.89
ULTIMATE SHEAR STRESS, T/SQ FT		$\tau_{ult}$	.65	1.33	2.71

TYPE OF SPECIMEN UNDISTURBED

3. IN. SQUARE .506 IN. THICK

CLASSIFICATION

LL 45

PL 14

PI 31

G. 2.7

REMARKS

PROJECT CHASKA FLOOD CONTROL NCS-1R-80-118-ED-HF

AREA NRD LAB NO: 80/227

BORING NO. 80-26H

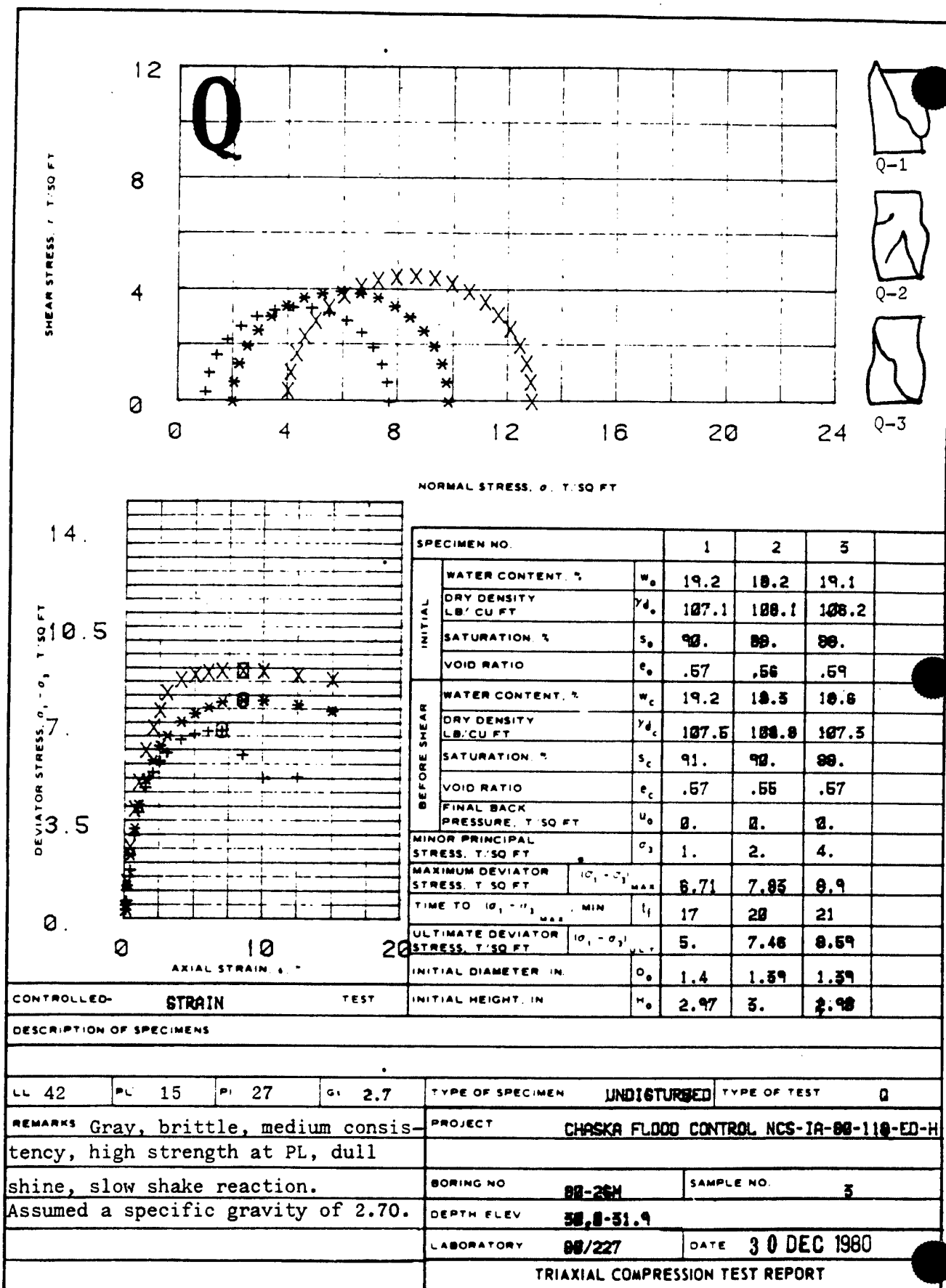
SAMPLE NO. 2

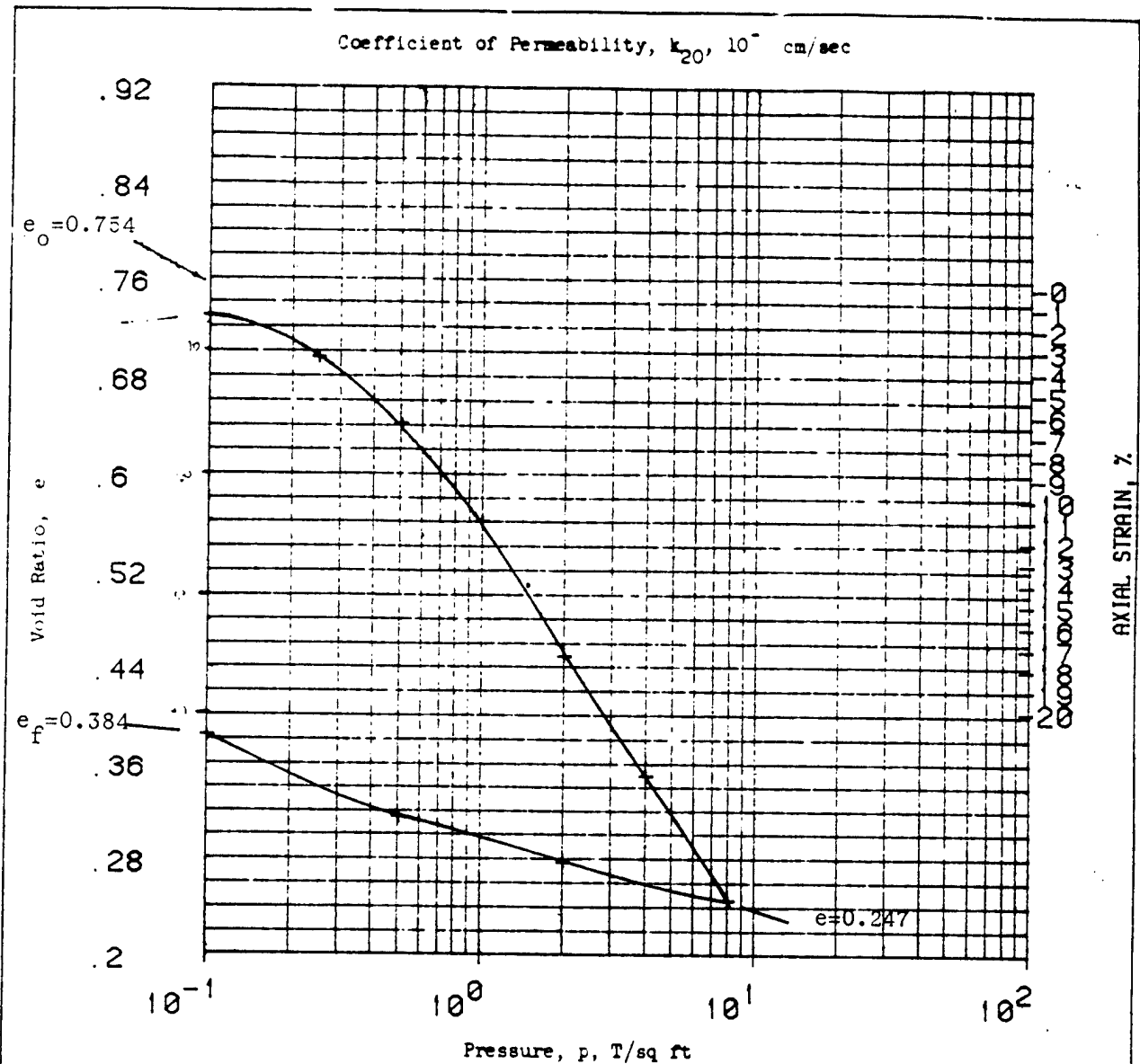
DEPTH 20.8-21.8

DATE 30 DEC 1980

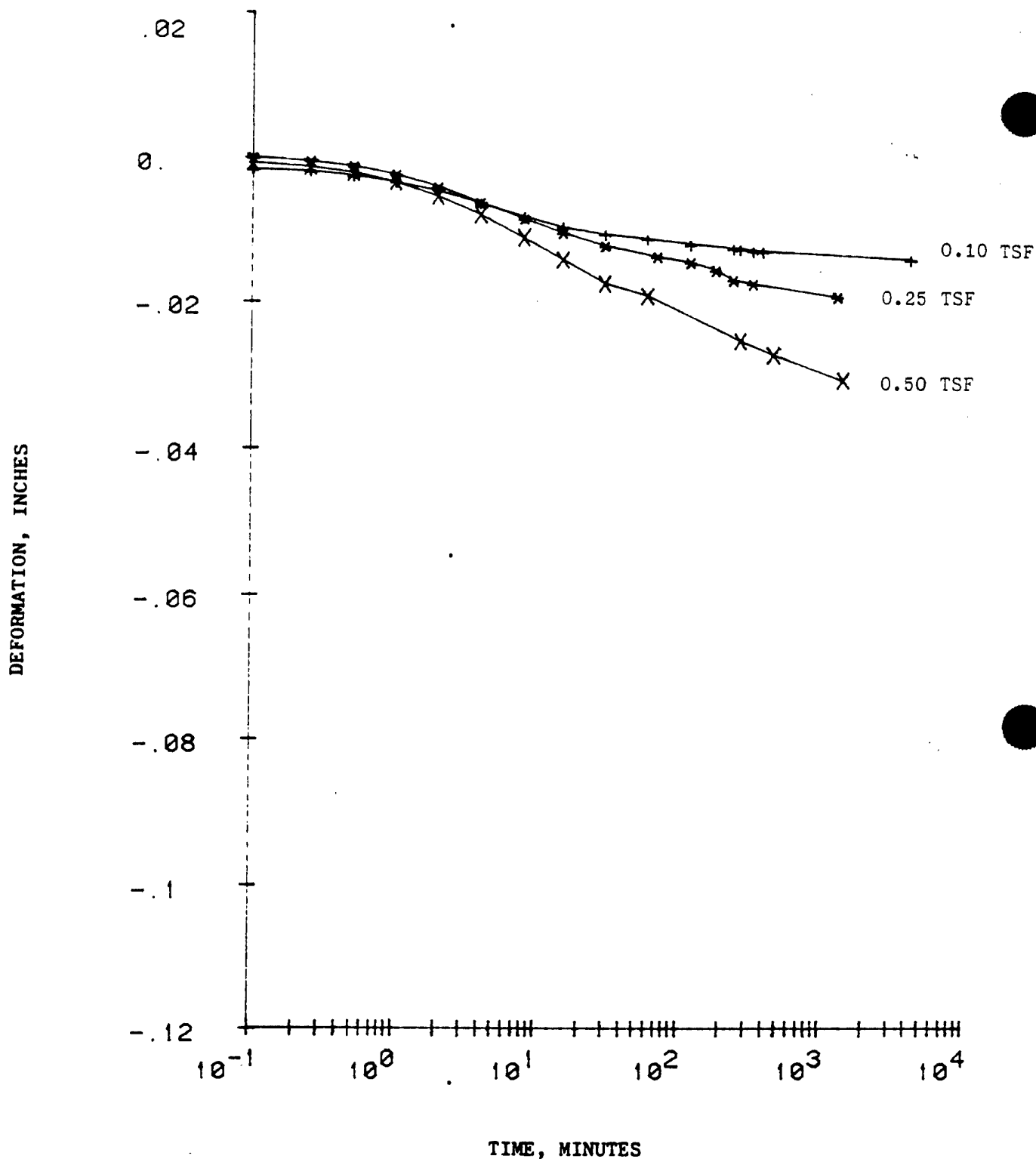
DIRECT SHEAR TEST REPORT

Figure C-41





Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.28 in.	Ht	1. in.	Water Content, $w_o$	6.9 %	$w_f$	4.7 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	.75	$e_f$	.38
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	23 %	$S_f$	31 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	91.1 lb/ft <sup>3</sup>		
Classification Organic, OH				$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec			
LL	86	$G_s$	2.56	Project			
PL	39	$D_{10}$		CHASKA NCS-1A-82-126-ED-6H			
Remarks Note the secondary				Area			
compression of Figures 7 & 8.				MRD LAB NO: 83/67			
				Boring No. 82-41MU		Sample No. 2	
				Depth		Date 17 FEB 1983	
				El			
<b>CONSOLIDATION TEST REPORT</b>							



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 2

DEPTH/ELEV: .

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

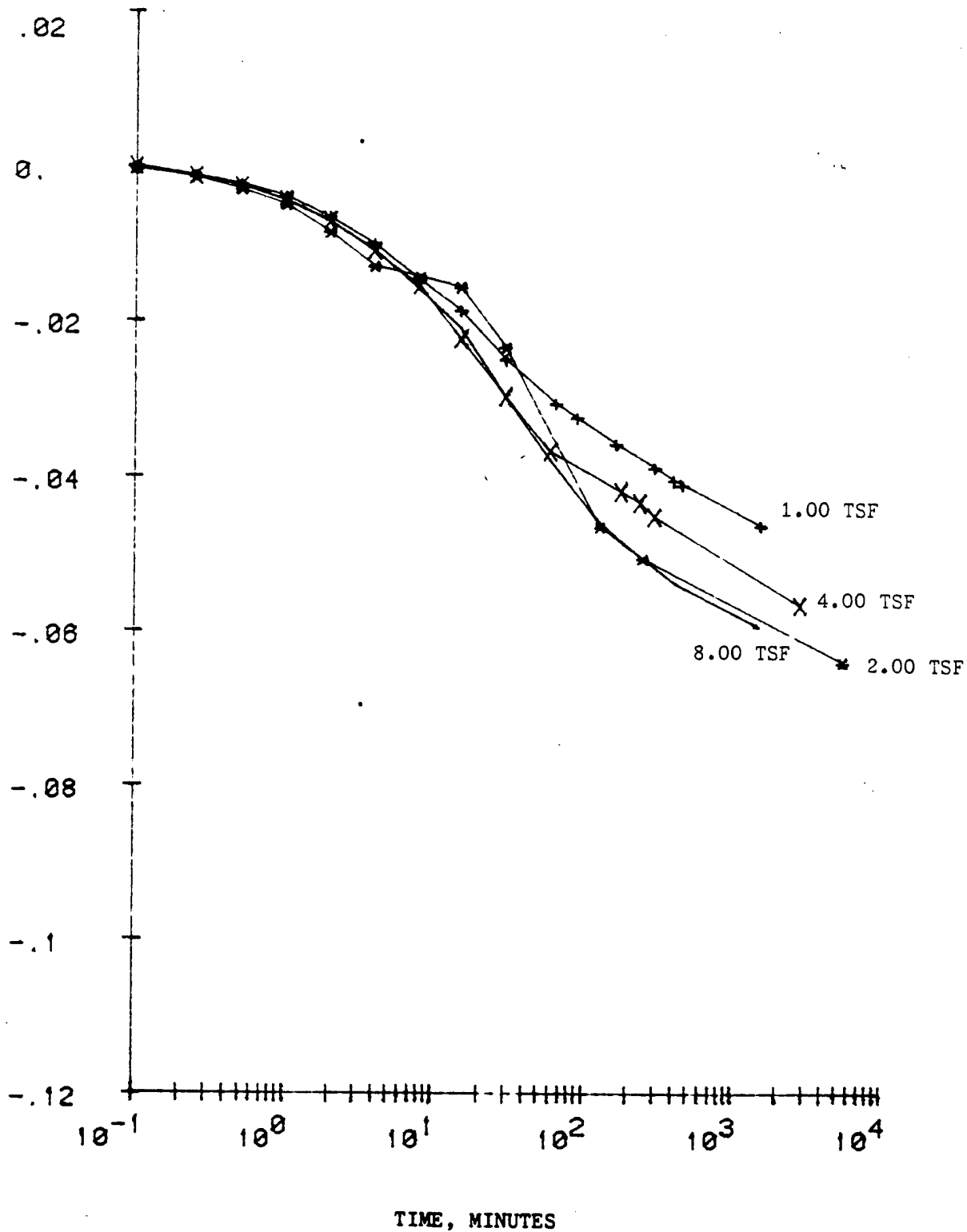
CONSOLIDATION TEST—TIME CURVES

FIGURE: 7

Figure C-44



DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 2

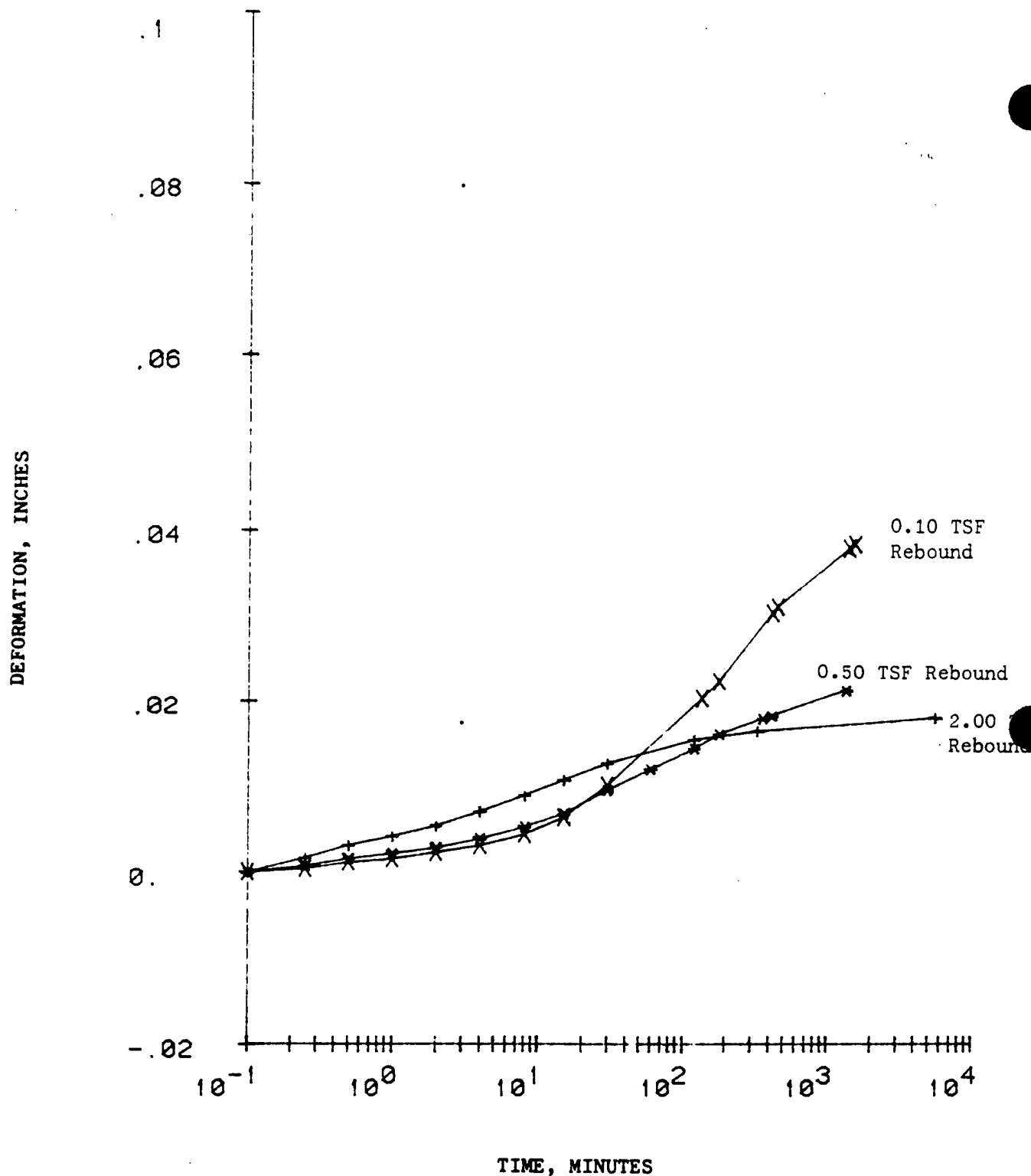
DEPTH/ELEV: .

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST--TIME CURVES

FIGURE: 8

Figure C-45



PROJECT: CHASKA MCS-1A-82-126-ED-6H

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU SAMPLE NO: 2

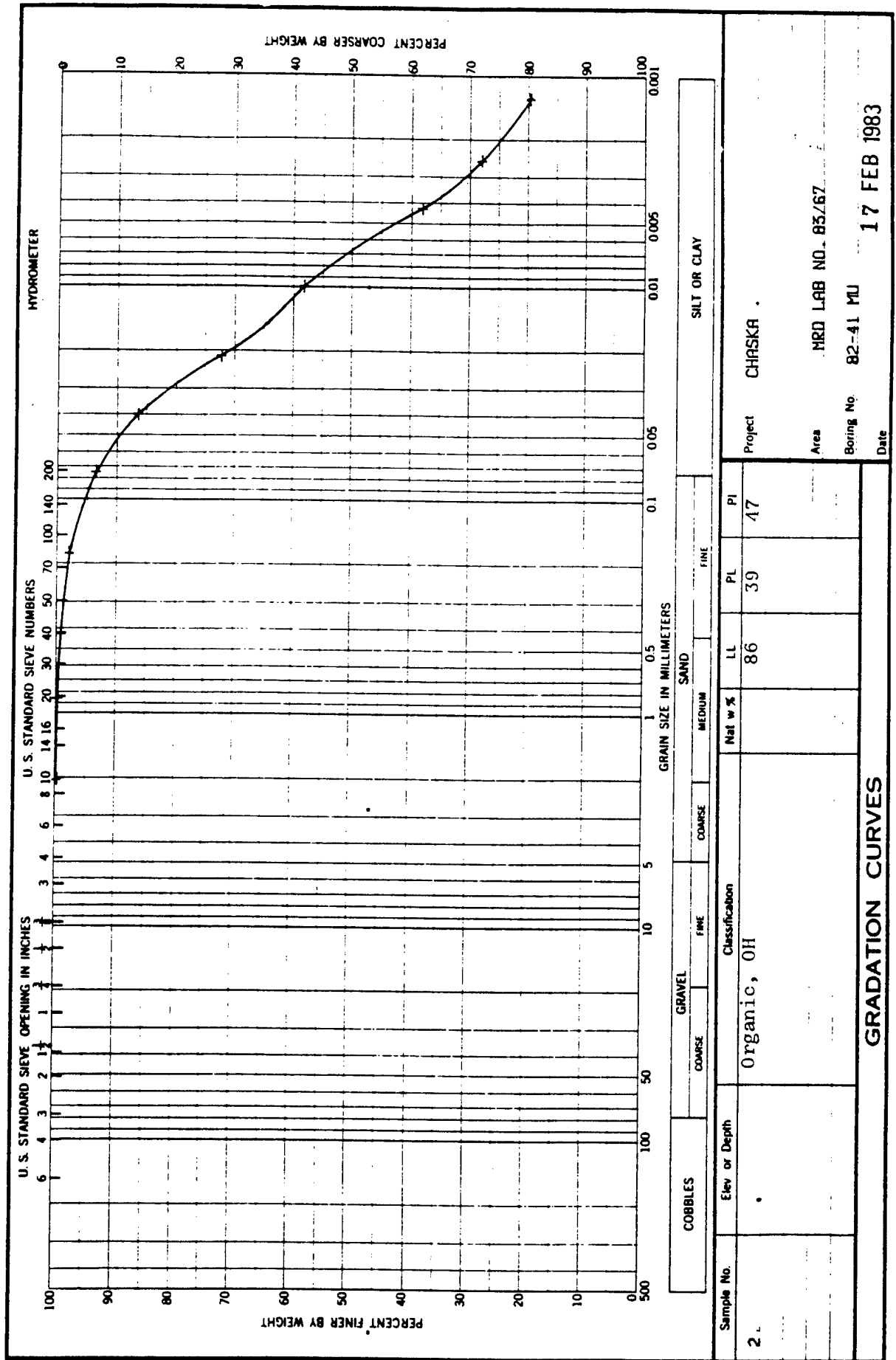
DEPTH/ELEV: .

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

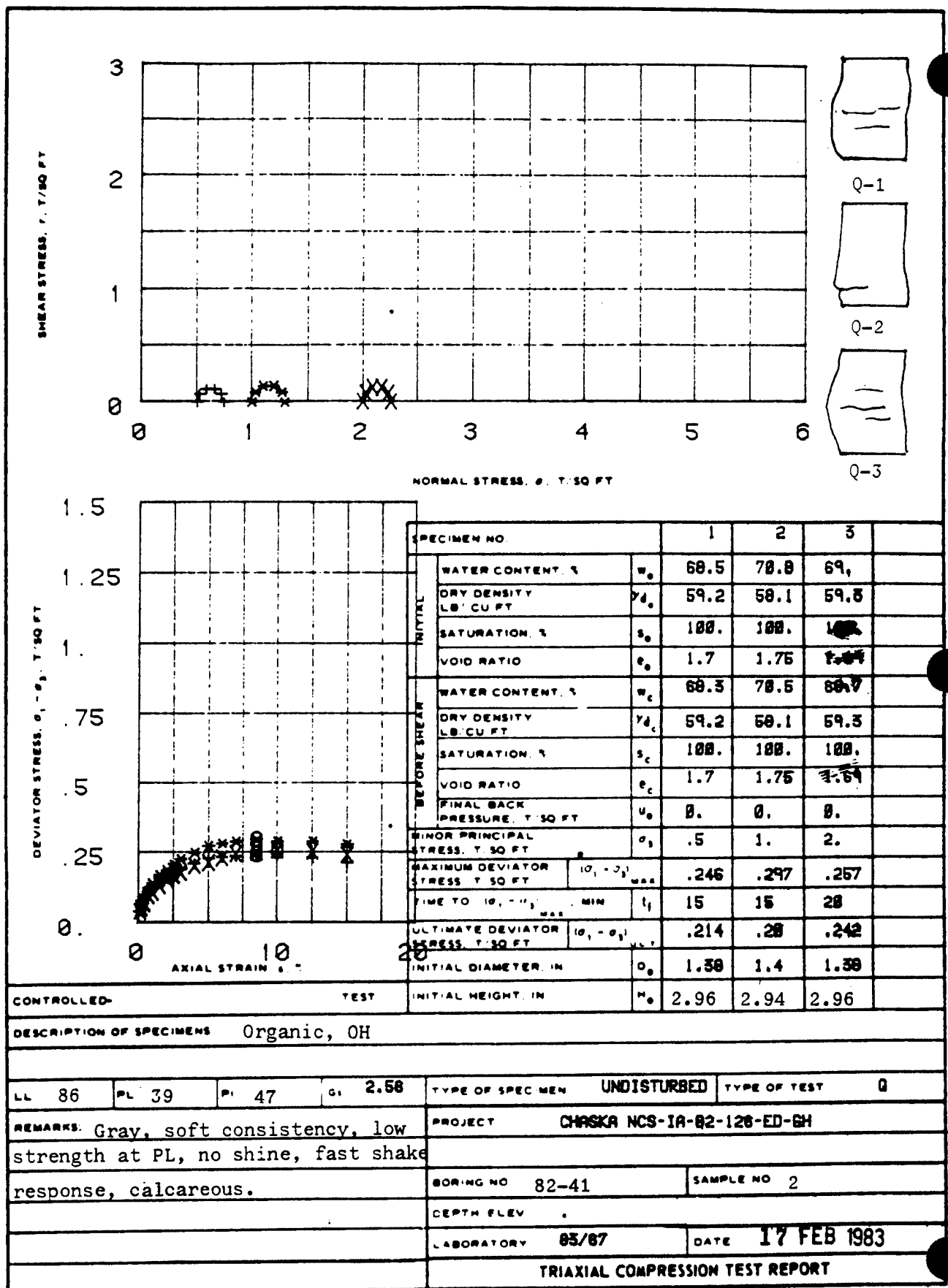
FIGURE: 9

Figure C-46

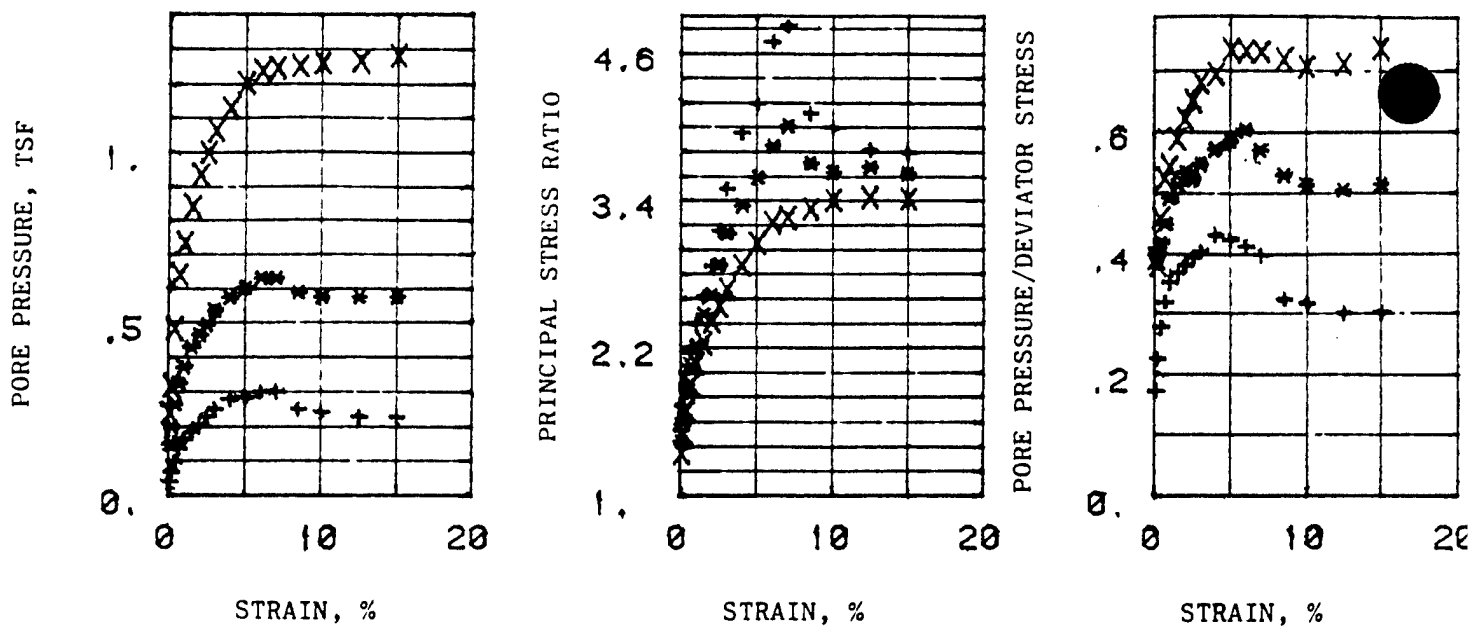


ENG FORM 2087  
1 MAY 63

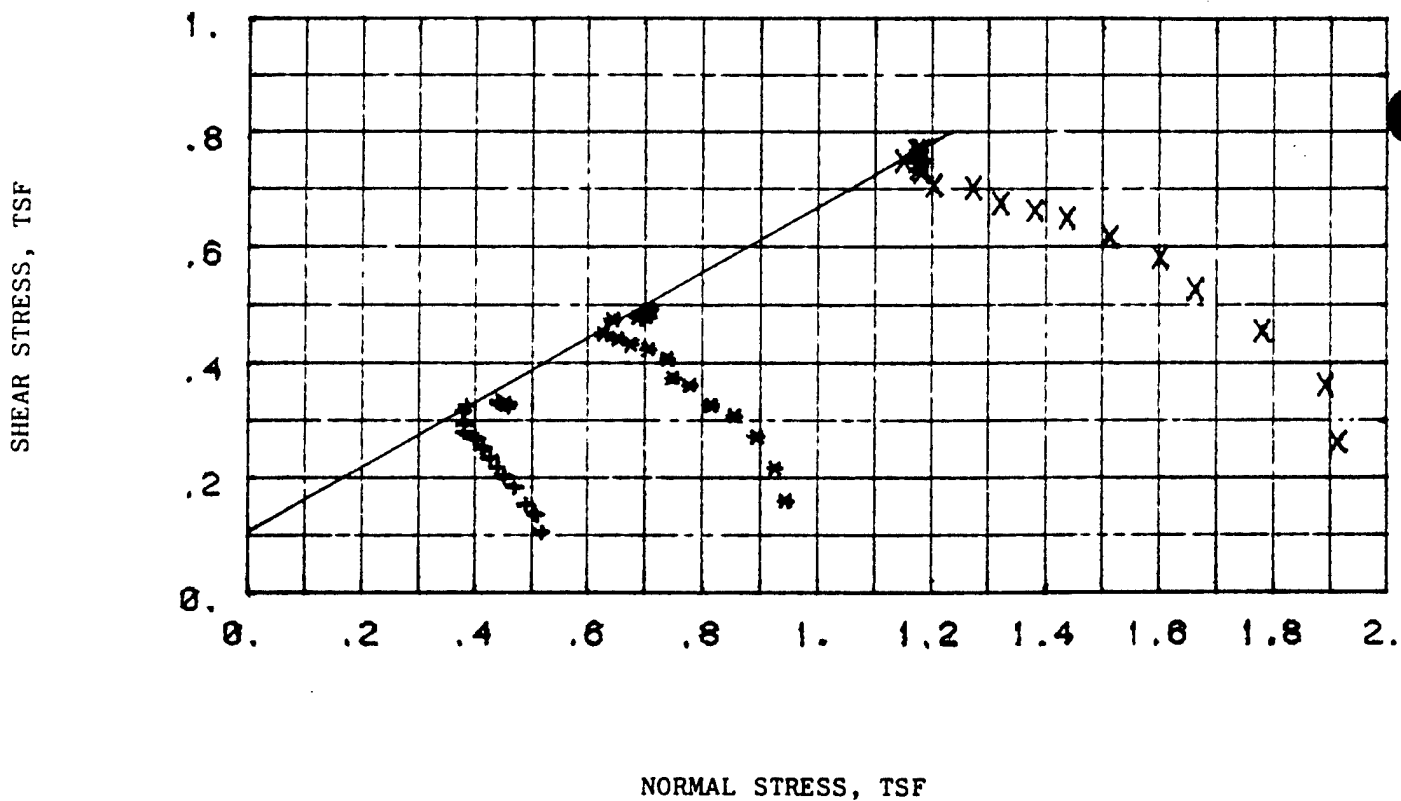
Figure C-47







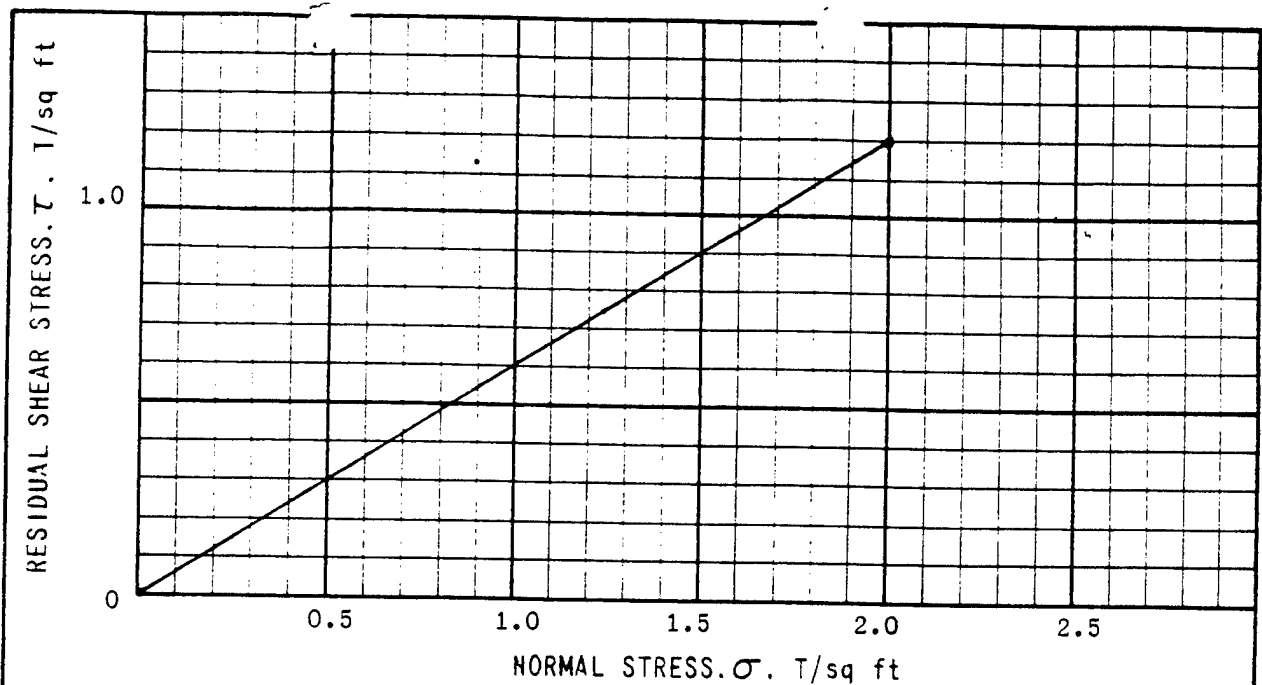
EFFECTIVE STRESS VECTOR CURVES ON 60-DEGREE PLANE



REMARKS: COMPUTER PRINT-OUT  
 SYMBOLS SAME AS FORM 2089  
 TRIAXIAL TEST: PORE PRESSURE  
 MONITORED DURING SHEAR

PROJECT: CHASKA MCS-1A-82-128-ED-NH  
 BORING NO: 44 SAMPLE NO: 2  
 DEPTH/ELEV: 5.5-6.7  
 MRD LAB NO: 83/87 DATE: 17 FEB 1983

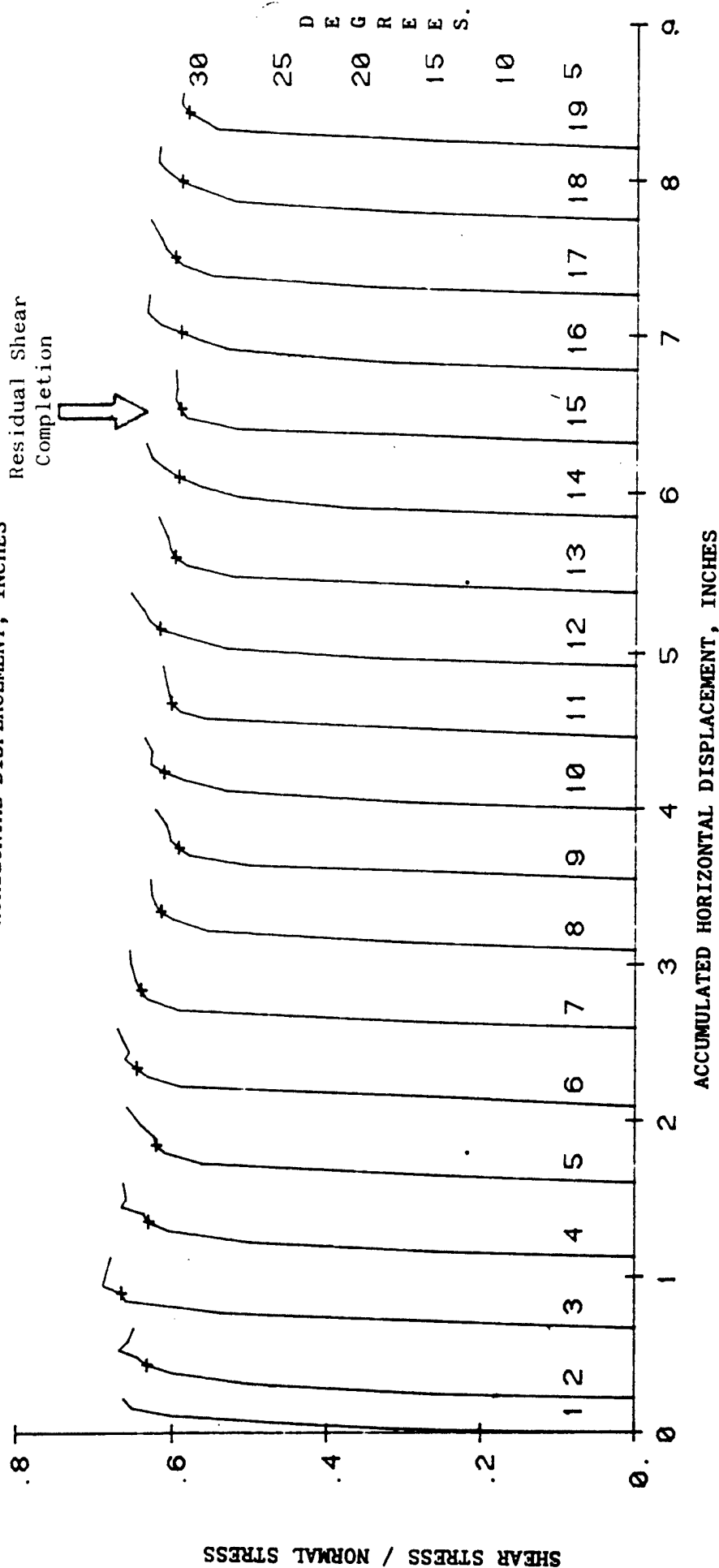
TRIAXIAL COMPRESSION TEST REPORT



TEST NO.			1			RESIDUAL SHEAR STRESS. T/sq ft	1.20		
INITIAL	WATER CONTENT	$w_o$	44.7			$\tau/\sigma$ AT RESIDUAL	0.60		
	VOID RATIO	$e_o$	1.12			TIME TO RESIDUAL, days	20.7		
	SATURATION	$S_o$	100			DISPLACEMENT TO RESIDUAL, inches	7.99		
	DRY DENSITY, lb/cu ft	$\rho_d$	75.4			FINAL SHEAR STRESS, T/sq ft	1.18		
SPECIFIC GRAVITY			$G_s$	2.56		FINAL DISPLACEMENT, inches	8.43		
LIQUID LIMIT			LL	86		LENGTH OF TEST, days	26.9		
PLASTIC LIMIT			PL	39		MATERIAL EXTRUDED, gms	11.9		
WATER CONTENT			$w_f$	28.6		MATERIAL EXTRUDED,	6.7		
NORMAL STRESS, T/sq ft			$\sigma$	2.0		SHEAR STRENGTH PARAMETERS	$\phi$ MAXIMUM	-	
MAXIMUM SHEAR STRESS, T/sq ft		$\tau_{max}$	-				$\phi$ RESIDUAL	31.0° *	
DISPLACEMENT TO MAXIMUM, inches		-					COHESION T/sq ft		

SPECIMEN DIMENSIONS 3.0 IN. SQUARE 0.5 IN. THICK.		MISSOURI RIVER DIVISION LABORATORY OMAHA NEBRASKA	
CONTROLLED <input checked="" type="checkbox"/> STRAIN <input type="checkbox"/> STRESS		PROJECT CHASKA LAB. NO. 83/67	
TYPE OF SPECIMEN Undisturbed, precut		AREA	
CLASSIFICATION Organic, OH		BORING NO. 2 87-41	SAMPLE NO. 2
*The residual shear test is meant for testing hard shales and the results may not be meaningful on this material.		DEPTH	DATE 17 FEB 1983
		ELEVATION 5.0-6.7	
RESIDUAL DIRECT SHEAR TEST REPORT			

SHEAR STRESS/NORMAL STRESS  
VS.  
ACCUMULATED HORIZONTAL DISPLACEMENT, INCHES



PULL NO:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
IN./DAY:	.22	.40	.15	.40	.49	.53	.52	.15	.45	.47	.46	.46	.16	.47	.51	.47	.47	.16	.53

SPECIMEN TYPE: UNDISTURBED, PRECUT

NORMAL STRESS, T/SF: 2.0

REMARKS:

PROJECT: CHASKA

BORING NO: 92-14 SAMPLE NO: 2

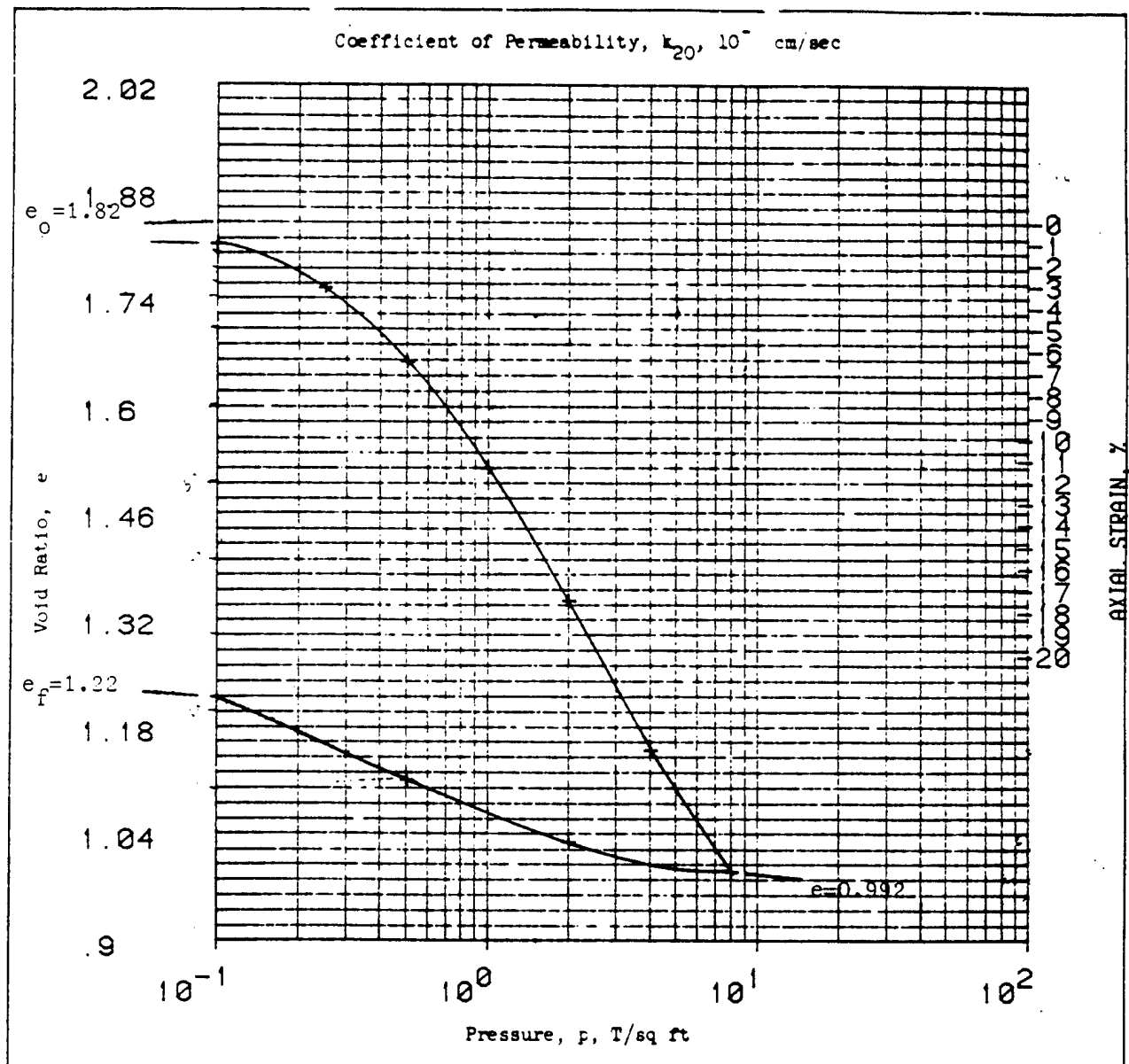
DEPTH: 5.8-6.7

MRD LAB NO: 85/87

DATE: 17 FEB 1983

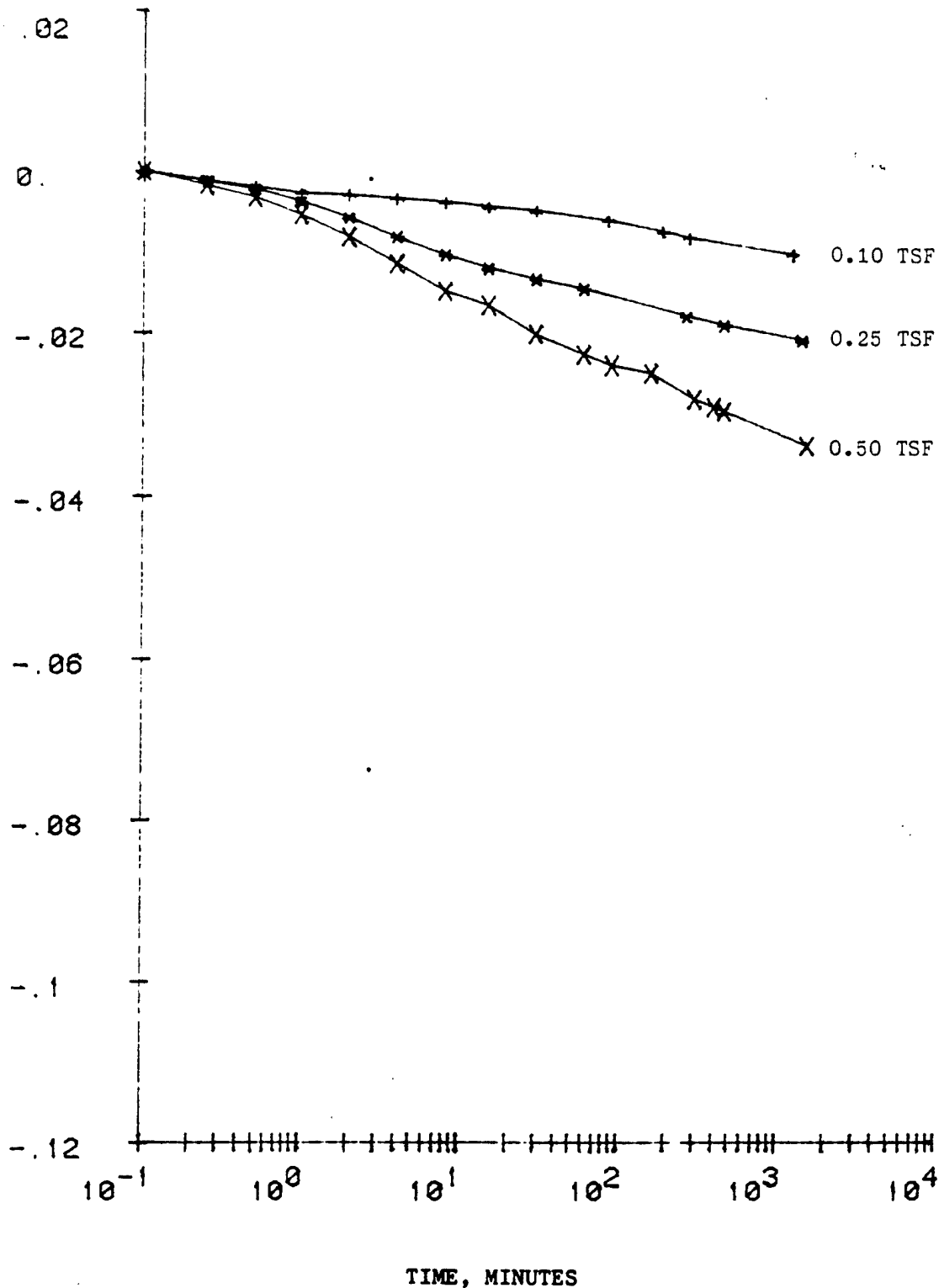
RESIDUAL DIRECT SHEAR TEST REPORT





Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.29 in.	Ht	.999 in.	Water Content, $w_o$	59.6 %	$w_f$	53.6 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	1.84	$e_f$	1.22
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	84 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	57.1 lb/ft <sup>3</sup>		
Classification Fat clay, CH (Organic)				$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL	81	$G_s$	2.6	Project			
PL	32	$D_{10}$		CHSRA NCS-1A-B2-126-ED-BH			
Remarks				Area			
				MRD LAB NO: 83/67			
				Boring No. 82-41MU		Sample No. 3	
				Depth		Date	
				El 10.8-12.8		17 FEB 1983	
<b>CONSOLIDATION TEST REPORT</b>							

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 65/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 3

DEPTH/ELEV: 10.8-12.8

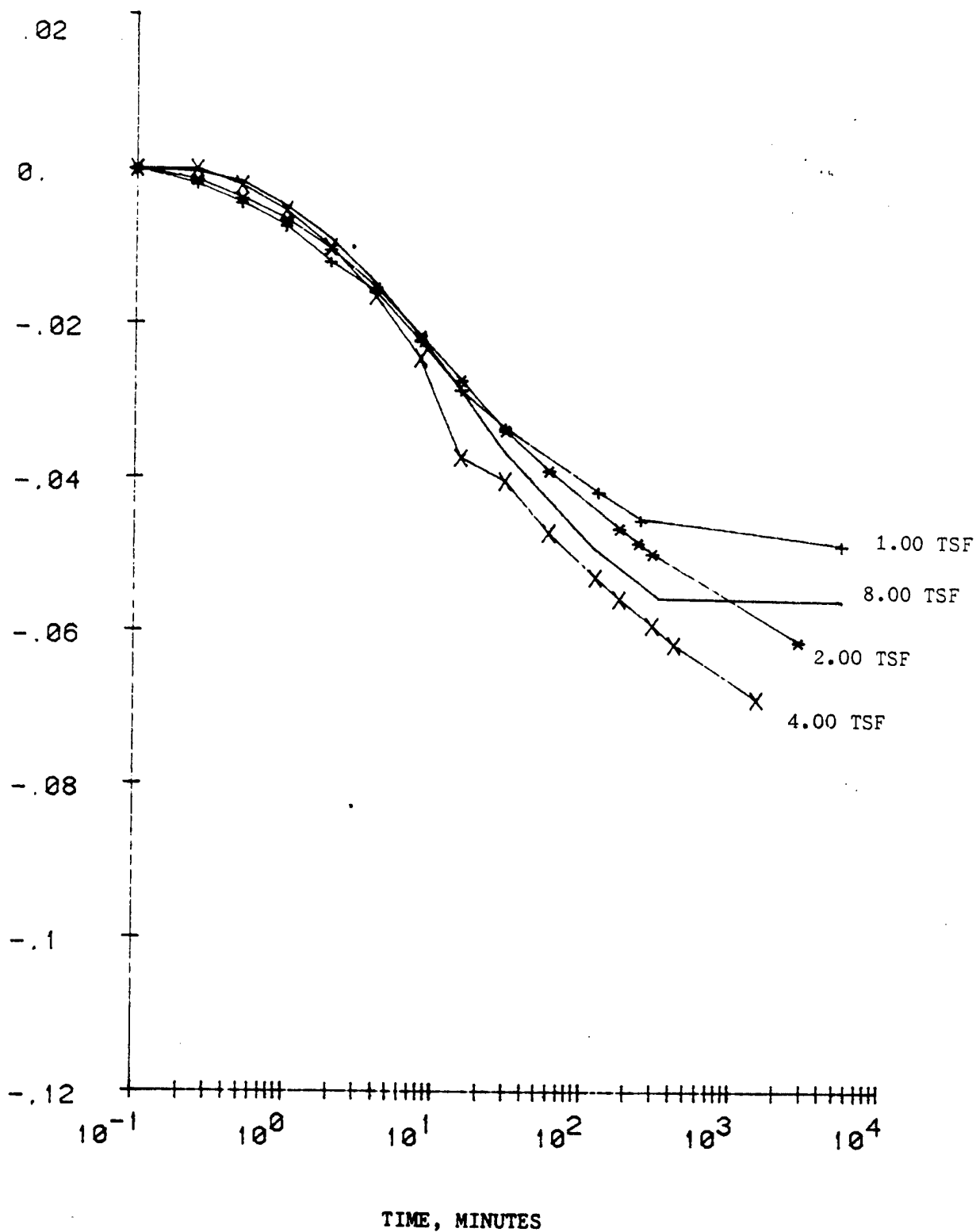
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 17

Figure C-54

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-02-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 3

DEPTH/ELEV: 10.8-12.0

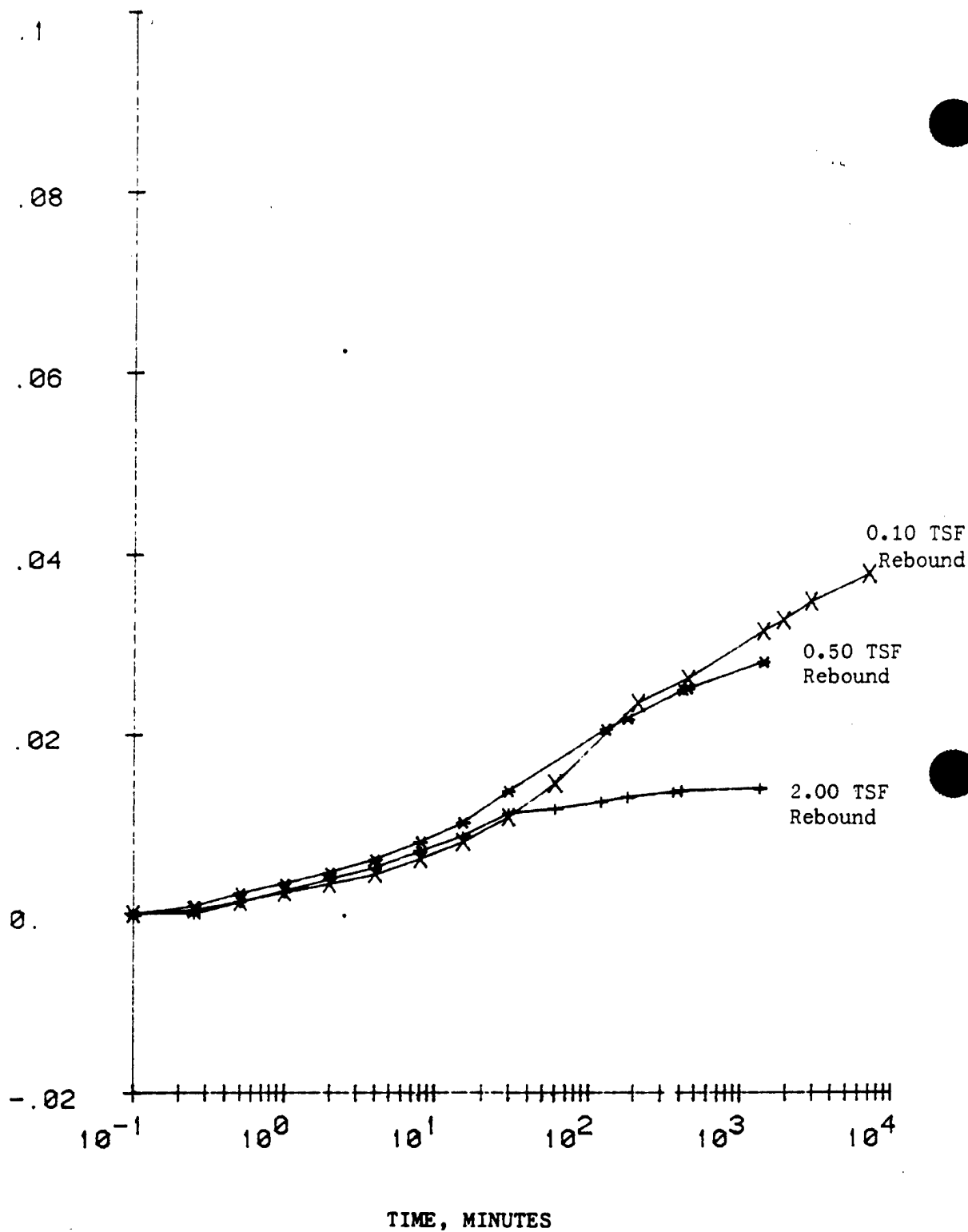
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 18

Figure C-55

DEFORMATION, INCHES



PROJECT: CHASKA NCS-IA-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU SAMPLE NO: 3

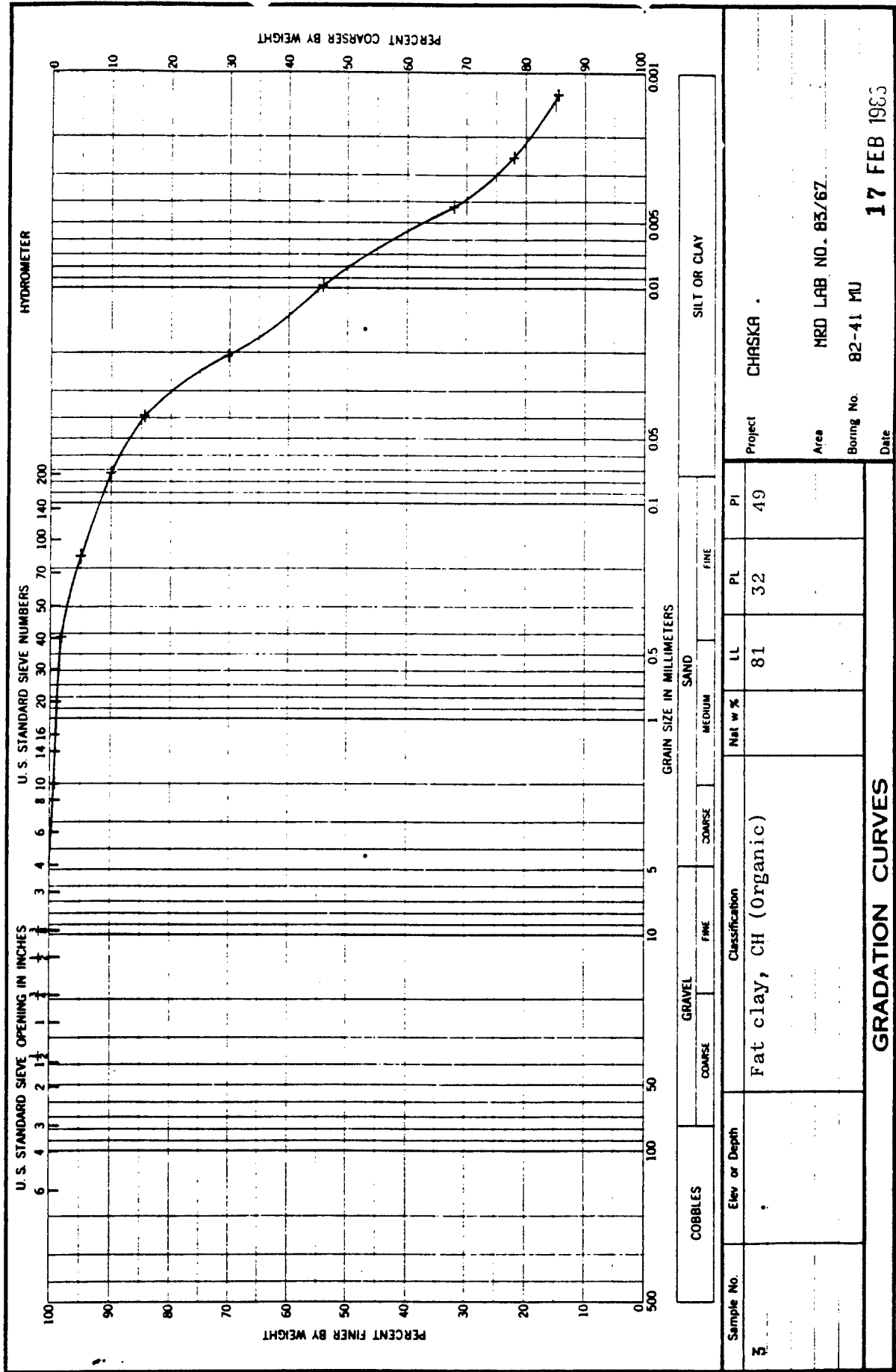
DEPTH/ELEV: 10.0-12.0

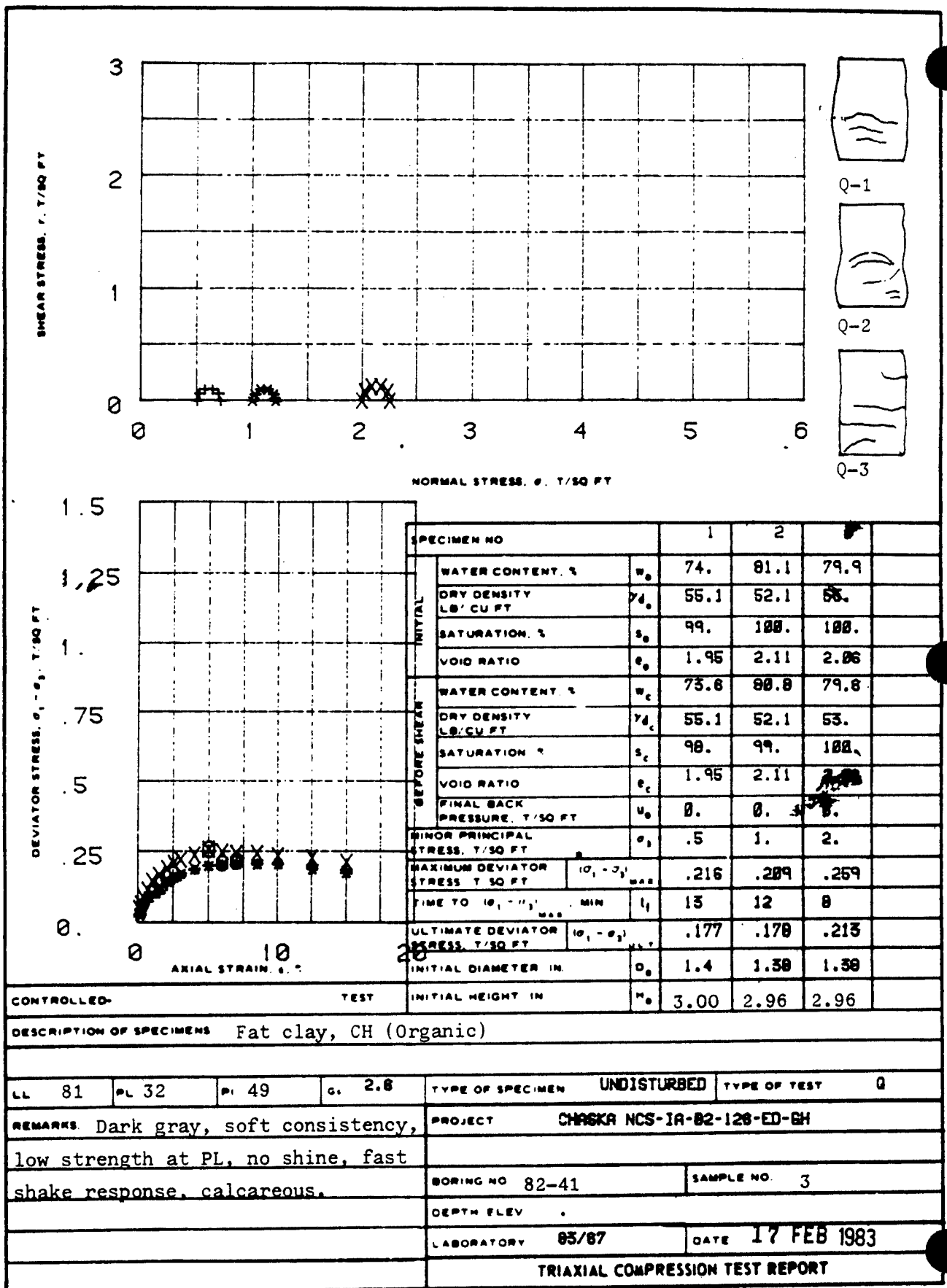
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

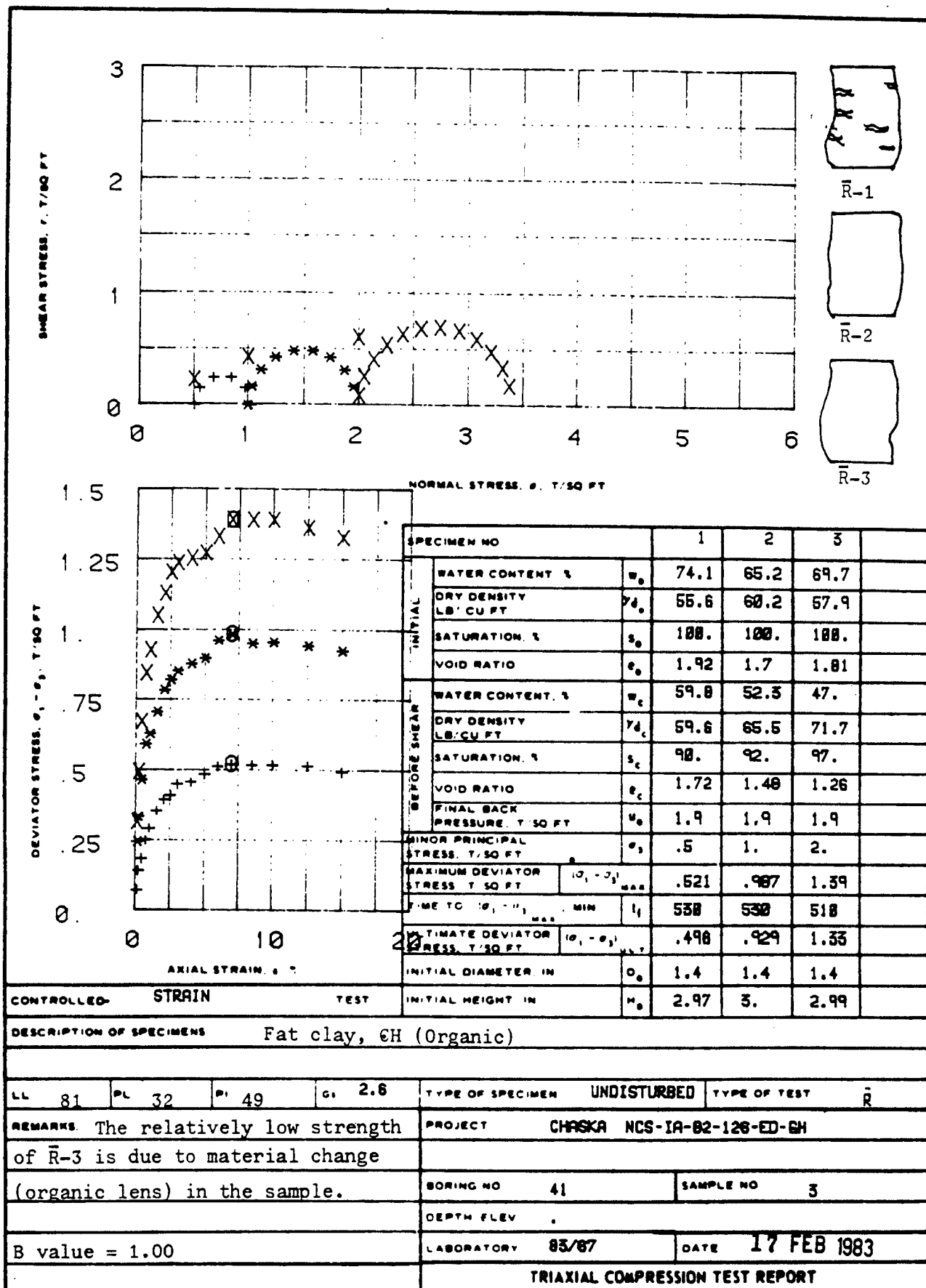
CONSOLIDATION TEST—TIME CURVES

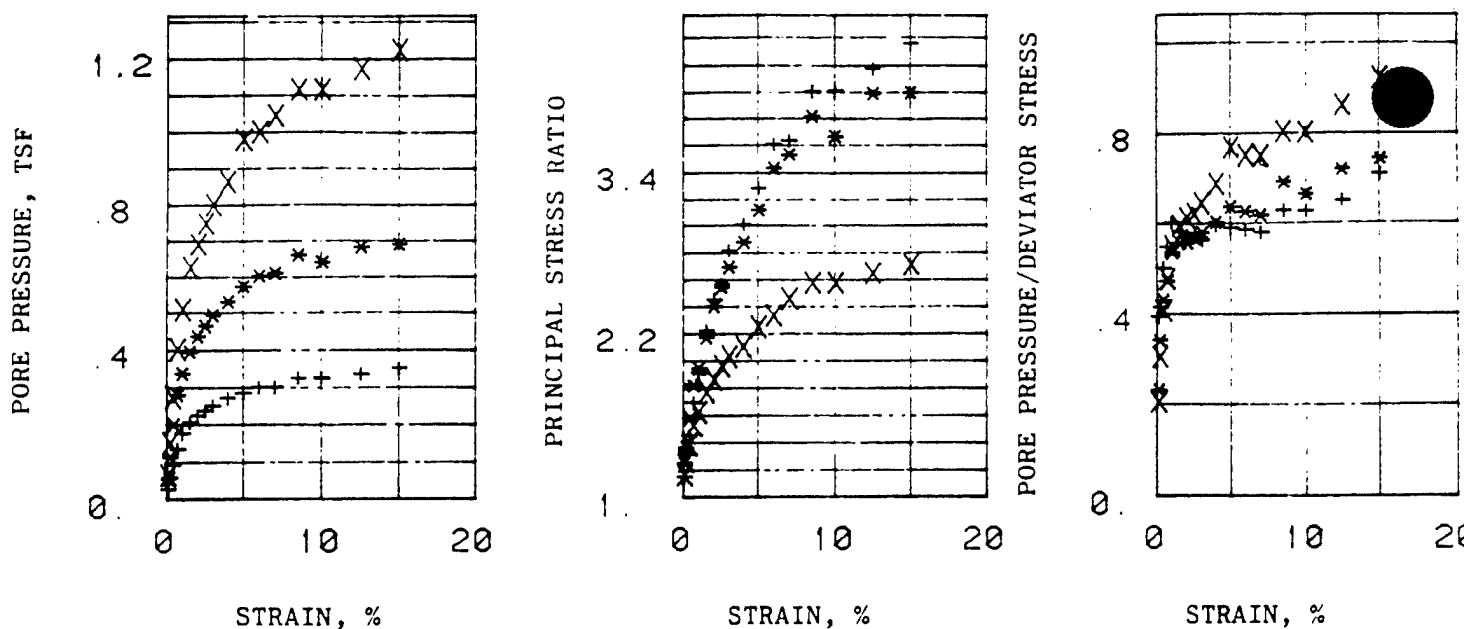
FIGURE: 19

Figure C-56

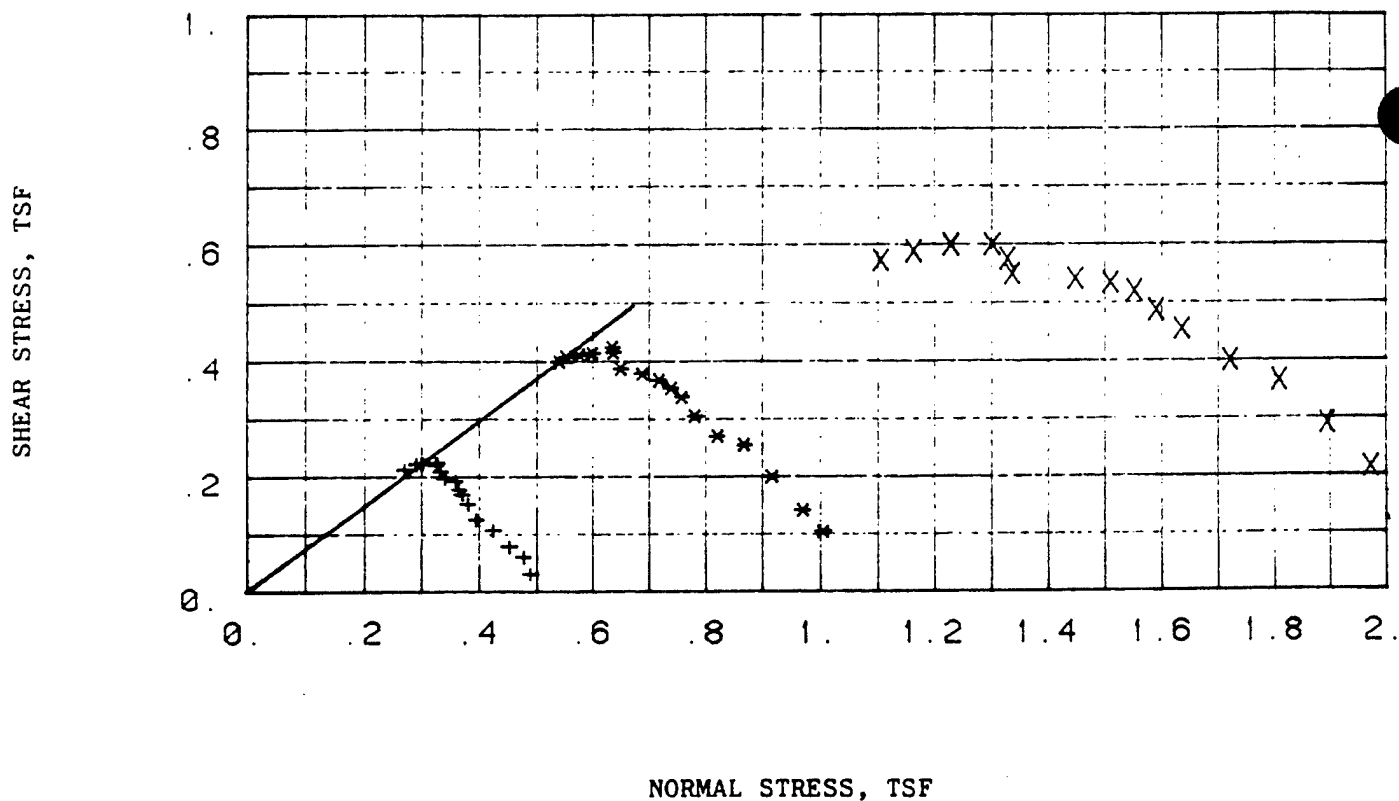








EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE

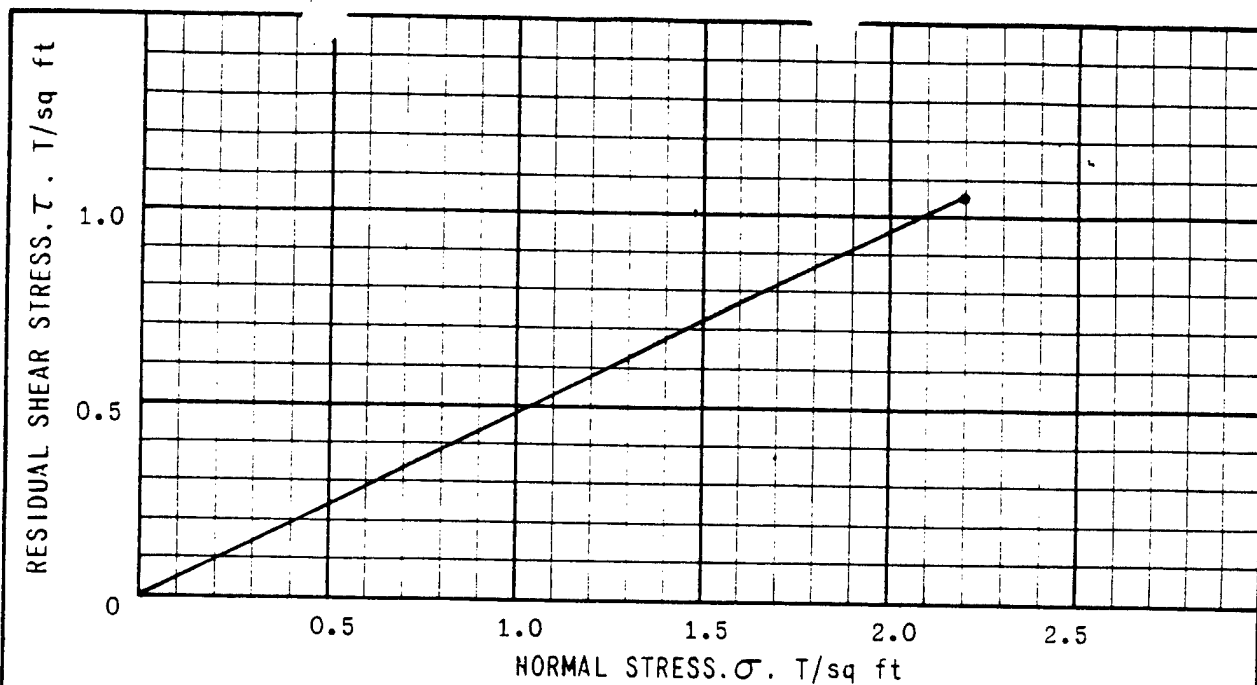


REMARKS: COMPUTER PRINT-OUT  
 SYMBOLS SAME AS FORM 2089  
 TRIAXIAL TEST: PORE PRESSURE  
 MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-82-126-ED-GH  
 BORING NO: 41 SAMPLE NO: 3  
 DEPTH/ELEV: .  
 MRD LAB NO: 85/87 DATE: 17 FEB 1983

TRIAXIAL COMPRESSION TEST REPORT

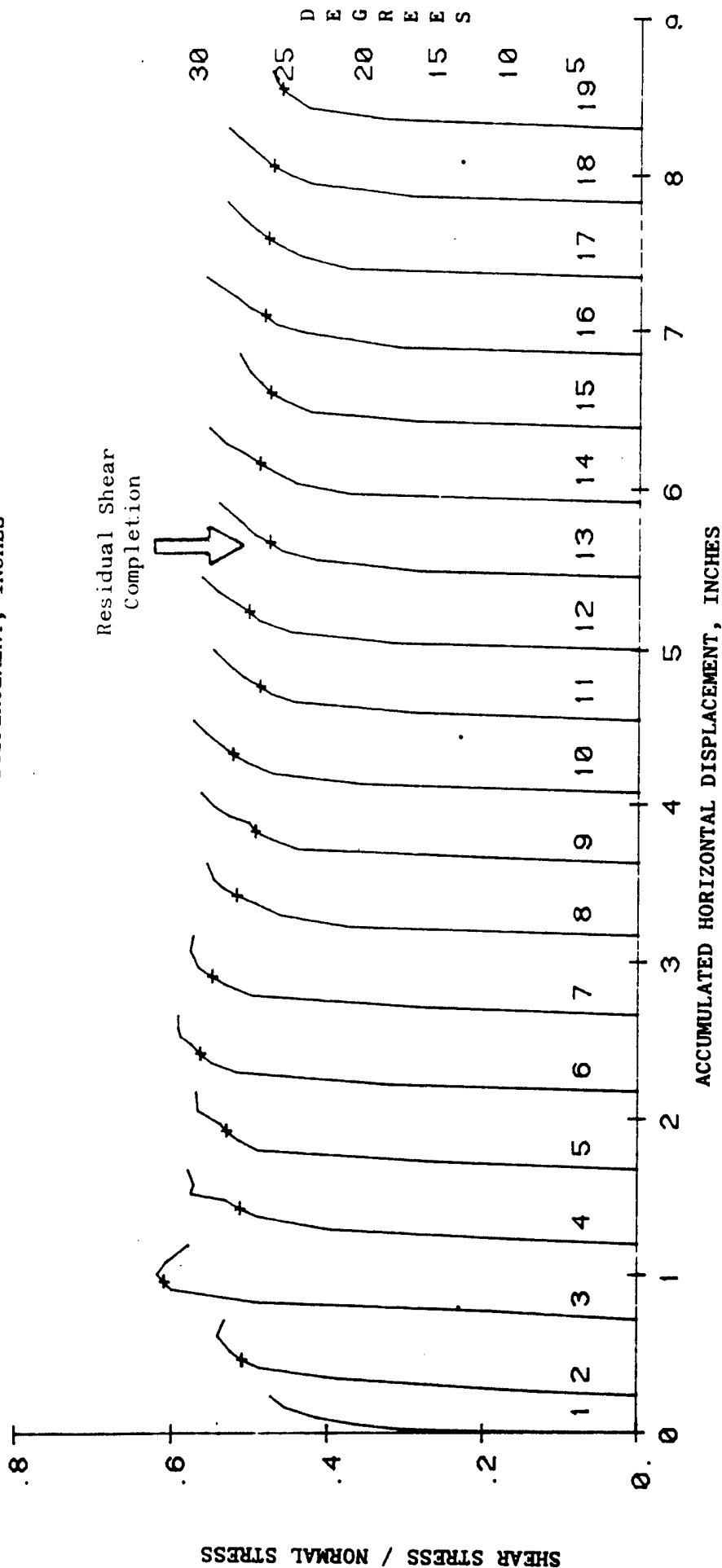




TEST NO.		1			RESIDUAL SHEAR STRESS. T/sq ft	1.06		
INITIAL	WATER CONTENT	w <sub>o</sub>	65.5		τ/σ AT RESIDUAL	0.48		
	VOID RATIO	e <sub>o</sub>	1.69		TIME TO RESIDUAL, days	18.2		
	SATURATION	S <sub>o</sub>	100.0		DISPLACEMENT TO RESIDUAL, inches	5.67		
	DRY DENSITY, lb/cu ft	γ <sub>d</sub>	51.8		FINAL SHEAR STRESS, T/sq ft	1.03		
SPECIFIC GRAVITY		G <sub>s</sub>	2.60		FINAL DISPLACEMENT, inches	8.5		
LIQUID LIMIT		LL	81		LENGTH OF TEST, days	26.6		
PLASTIC LIMIT		PL	32		MATERIAL EXTRUDED, gms	5.0		
WATER CONTENT		w <sub>f</sub>	40.0		MATERIAL EXTRUDED,	3.6		
NORMAL STRESS, T/sq ft		σ	2.2		SHEAR STRENGTH PARAMETERS	φ MAXIMUM	-	
MAXIMUM SHEAR STRESS, T/sq ft		τ <sub>max</sub>	-			φ RESIDUAL	25.6°*	
DISPLACEMENT TO MAXIMUM, inches		-				COHESION T/sq ft	0	

SPECIMEN DIMENSIONS 3.0 IN. SQUARE 0.5 IN. THICK		MISSOURI RIVER DIVISION LABORATORY OMAHA, NEBRASKA	
CONTROLLED <input checked="" type="checkbox"/> STRAIN <input type="checkbox"/> STRESS		PROJECT Chaska	LAB. NO. 83/67
TYPE OF SPECIMEN Undisturbed, precut		AREA	
CLASSIFICATION Fat clay, CH (Organic)	BORING NO. 82-41	SAMPLE NO. 3	
*The residual shear test is normally used on hard shales and these results may not be meaningful.	DEPTH ELEVATION 10.0-12.0	DATE 17 FEB 1983	
RESIDUAL DIRECT SHEAR TEST REPORT			

SHEAR STRESS/NORMAL STRESS  
VS.  
ACCUMULATED HORIZONTAL DISPLACEMENT, INCHES



PULL NO:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
IN./DAY:	.23	.51	.15	.15	.49	.5	.52	.52	.15	.46	.47	.46	.16	.47	.49	.48	.48	.16	.55

SPECIMEN TYPE: UNDISTURBED, PRECUT

NORMAL STRESS, T/SF: 2.2

REMARKS:

PROJECT: CHASKA

BORING NO: 82-41 SAMPLE NO: 3

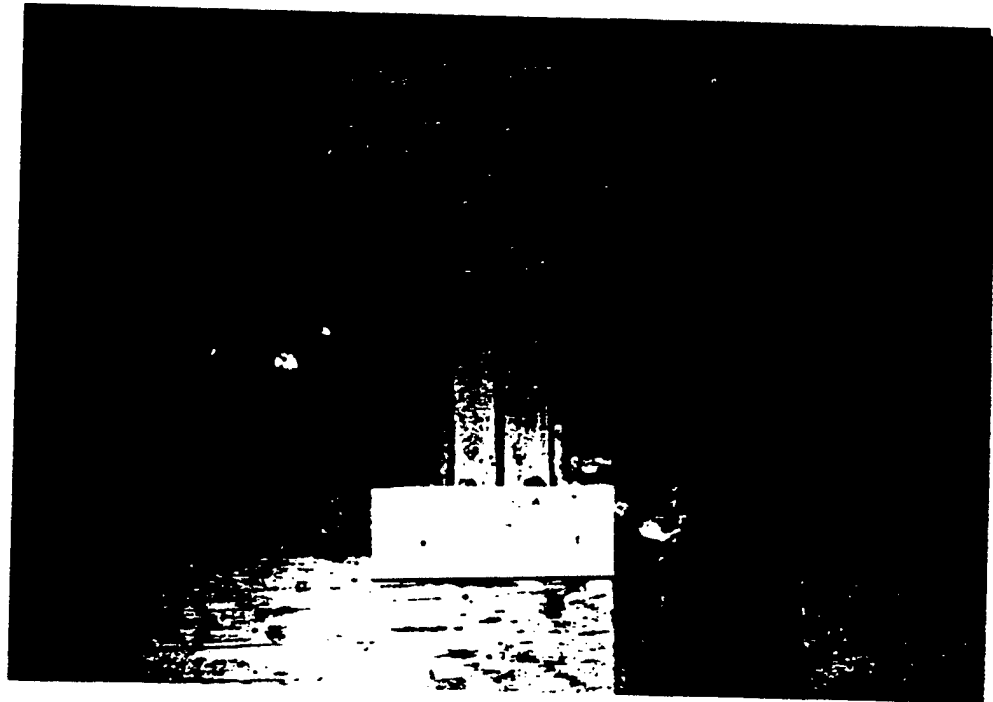
DEPTH: 10.8-12.0

MRD LAB NO: 85/87 DATE: 17 FEB 1983

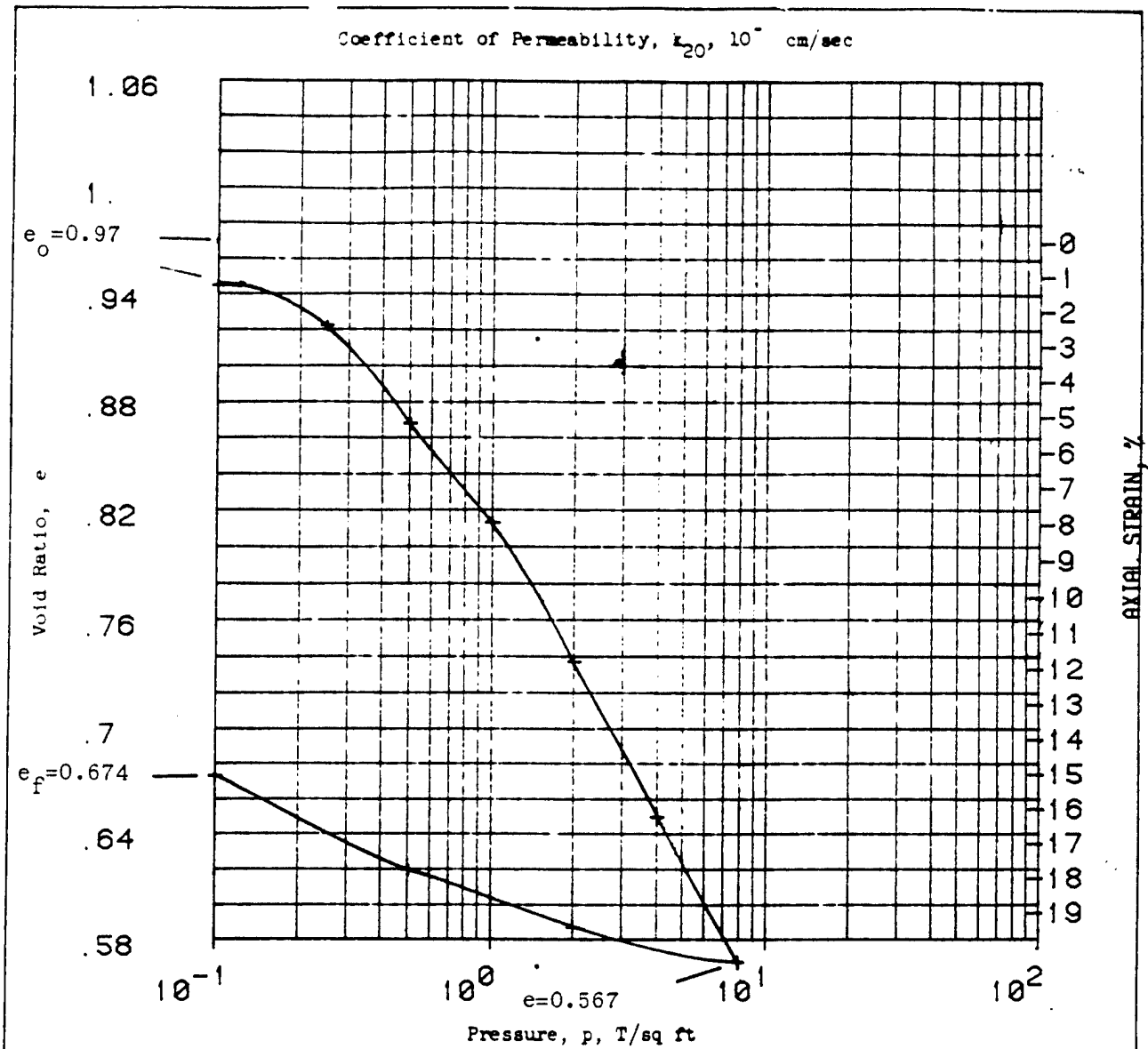
RESIDUAL DIRECT SHEAR TEST REPORT

FIGURE: 15

DEPARTMENT OF THE ARMY  
Missouri River Division, Corps of Engineers  
Division Laboratory  
Omaha, Nebraska

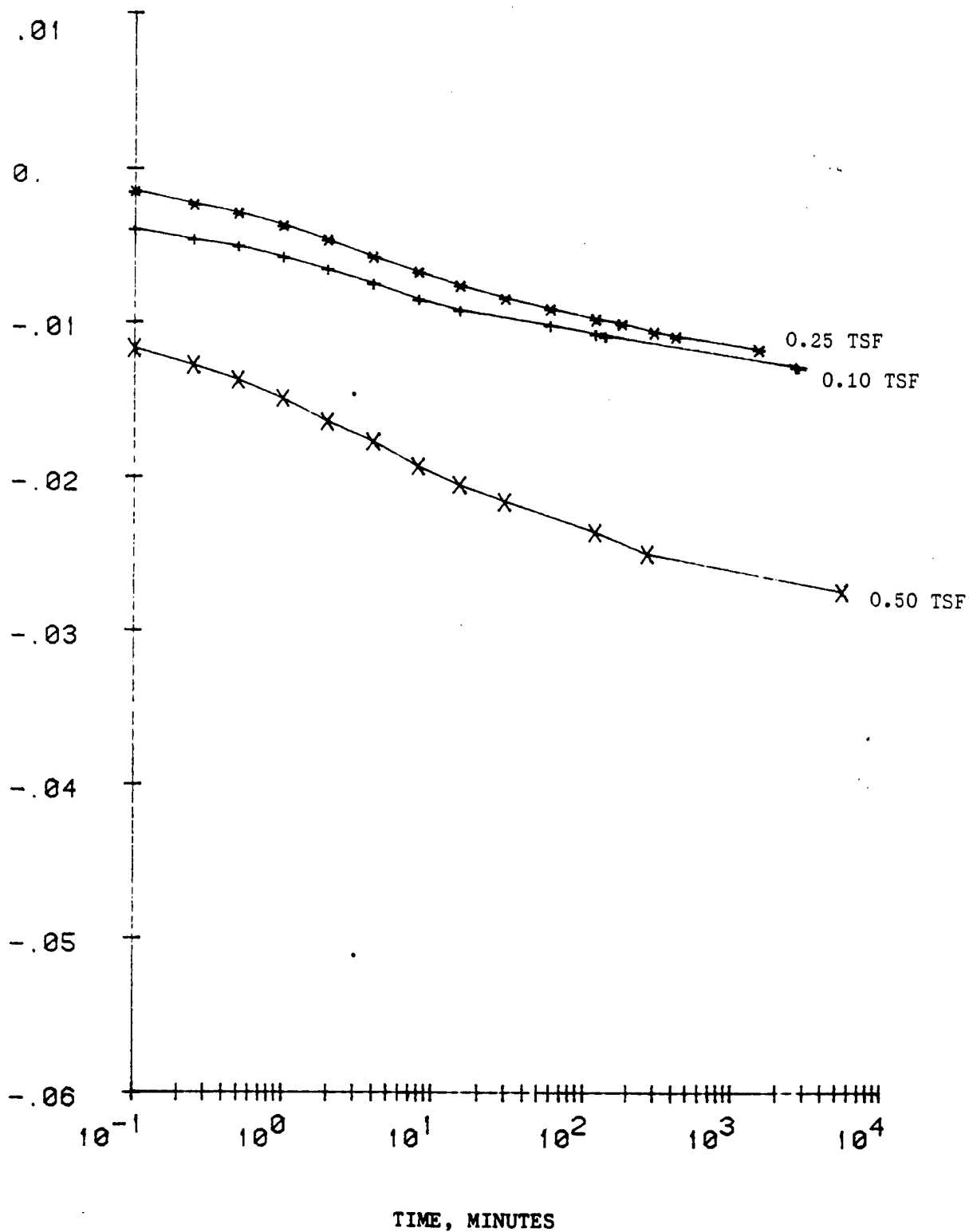


Residual Shear Test Boring 83-41 Sample 3



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	.999 in.	Water Content, $w_o$	34.8 %	$w_f$	26.6 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	.97	$e_f$	.67
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	96. %	$S_f$	100. %
Compression Index, $C_c$				Dry Density, $\gamma_d$	84.6 lb/ft <sup>3</sup>		
Classification		Sandy clay, CH		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL	56	$G_s$	2.67	Project			
PL	19	$D_{10}$		CHASKA NCS-1A-B2-126-ED-6H			
Remarks Note the high secondary consolidation.				Area			
				MRD LAB NO: 83/67			
				Boring No. 82-41MU		Sample No. 4	
				Depth El 10.0-19.2		Date 17 FEB 1983	
				<b>CONSOLIDATION TEST REPORT</b>			

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 4

DEPTH/ELEV: 10.0-19.2

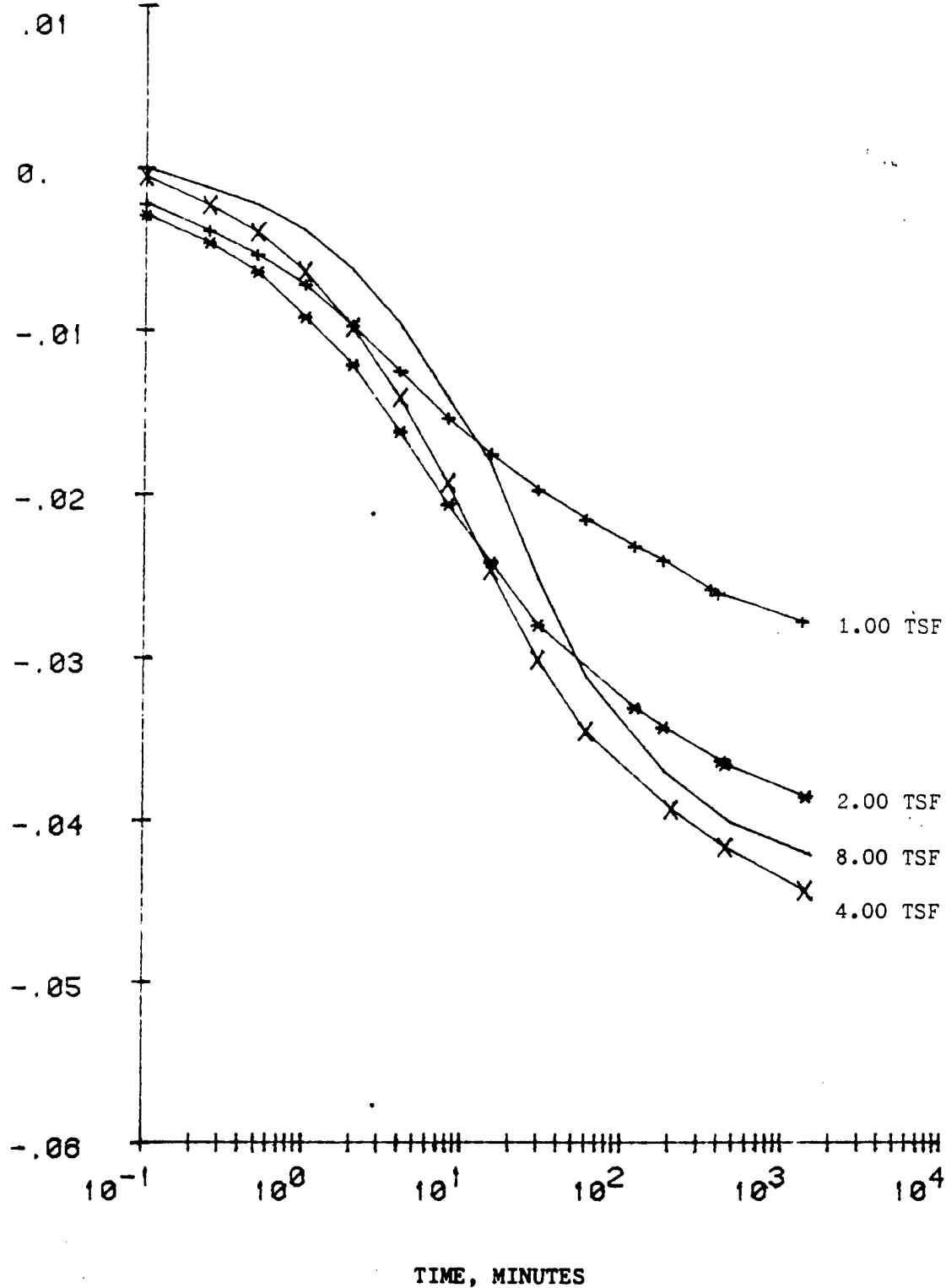
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 27

Figure C-65

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 4

DEPTH/ELEV: 18.8-19.2

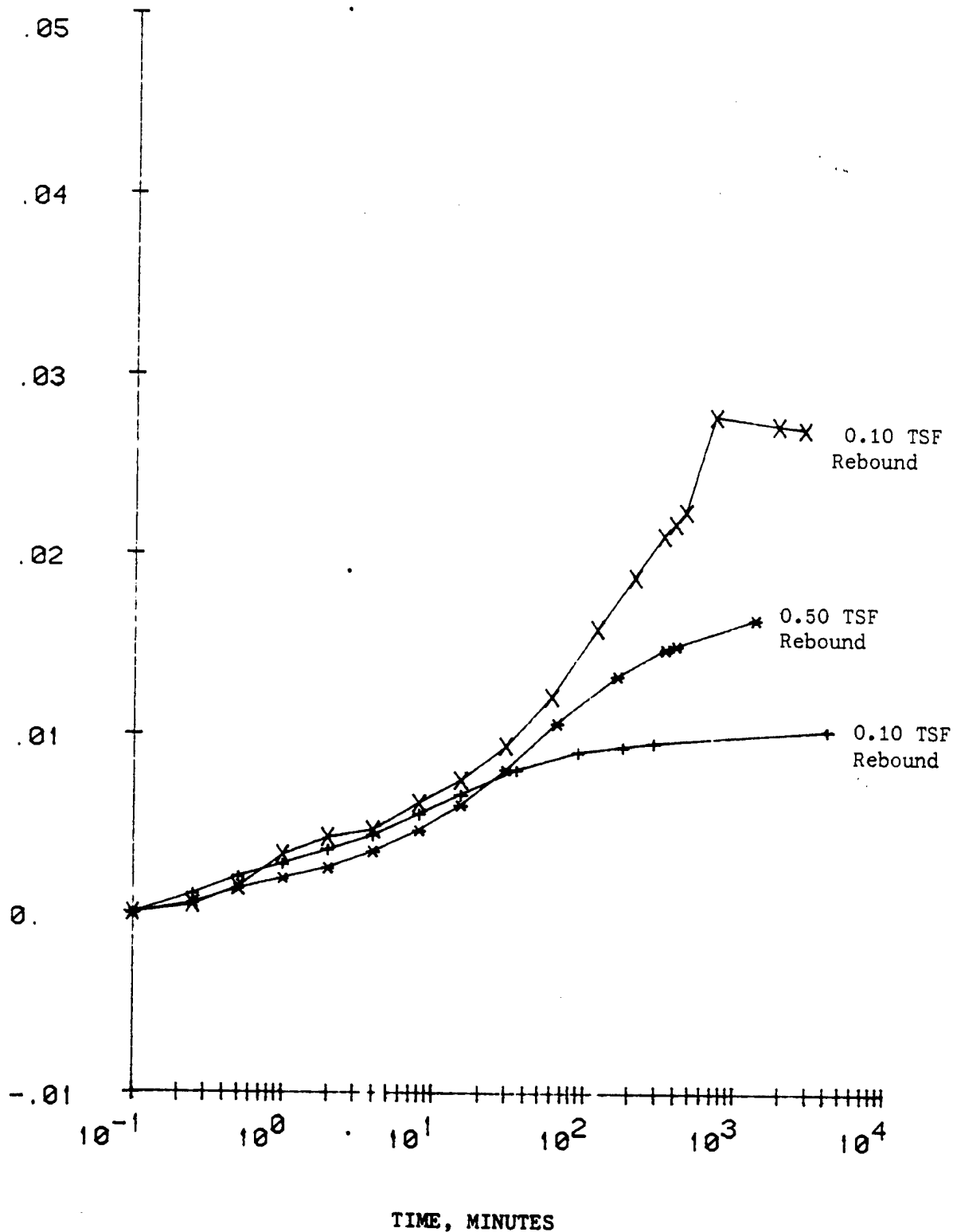
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 28

Figure C-66

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 17 FEB 1983

BORING NO: 82-41MU

SAMPLE NO: 4

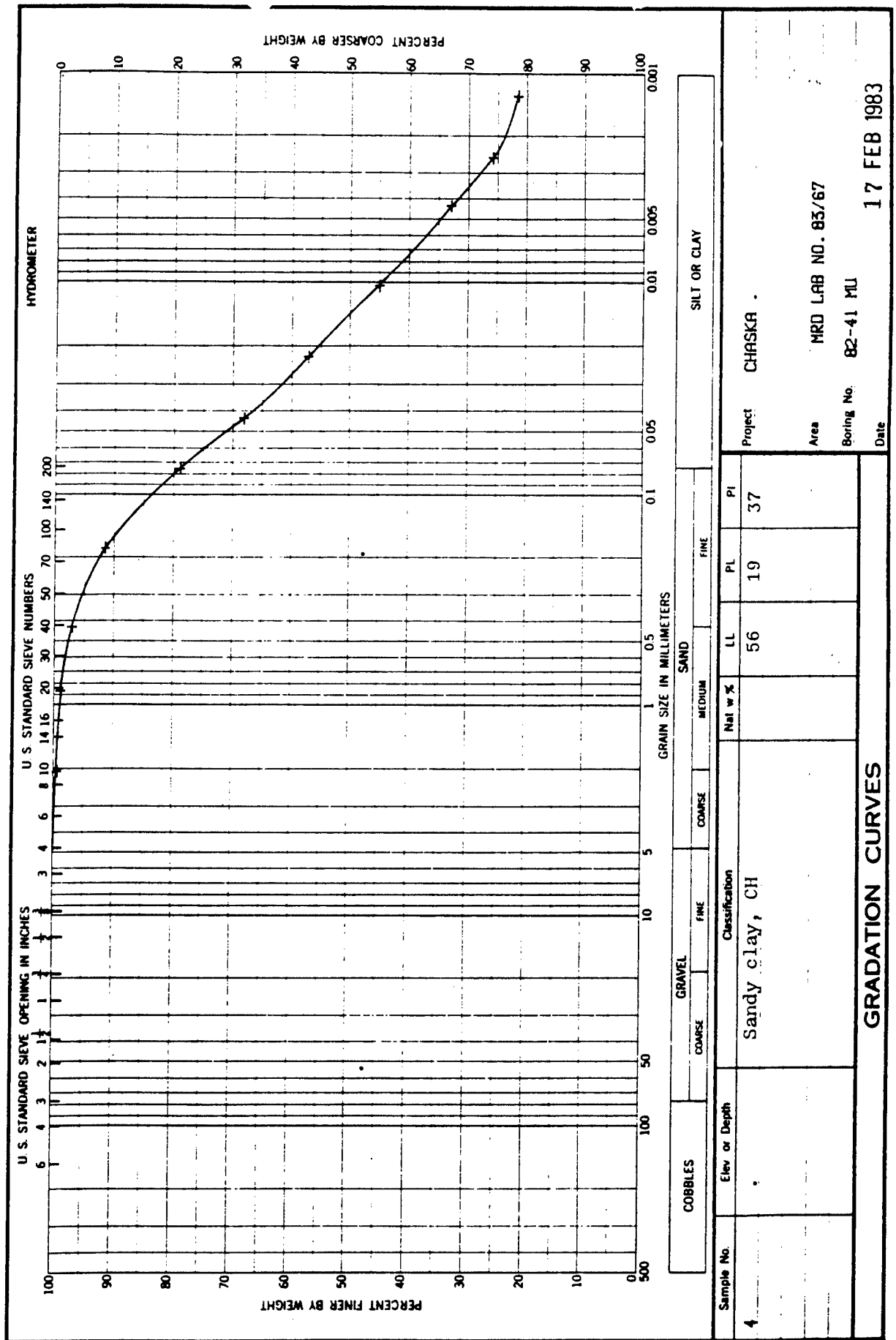
DEPTH/ELEV: 18.8-19.2

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 29

Figure C-67



ENG 1 MAR 1987

Figure C-68

FIGURE



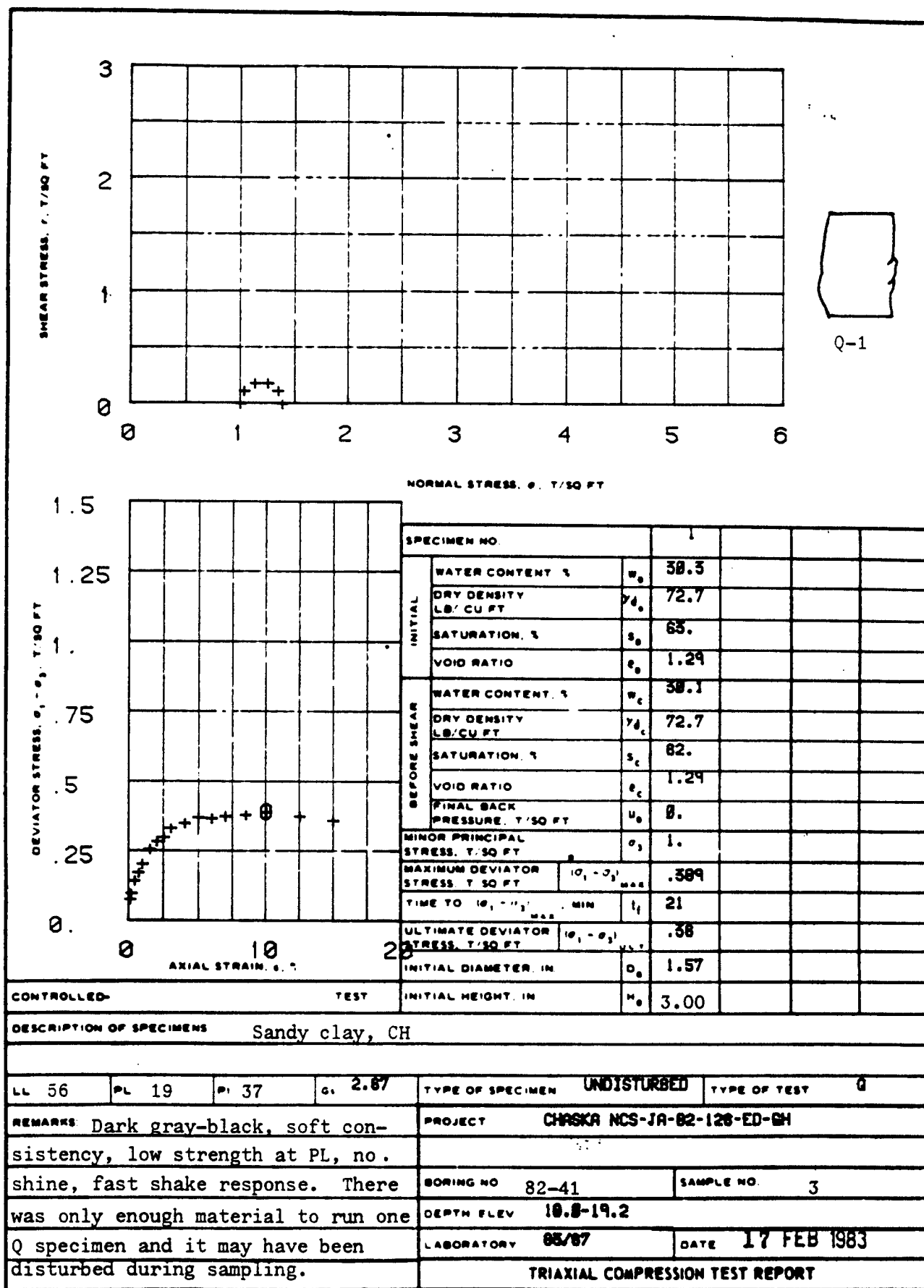
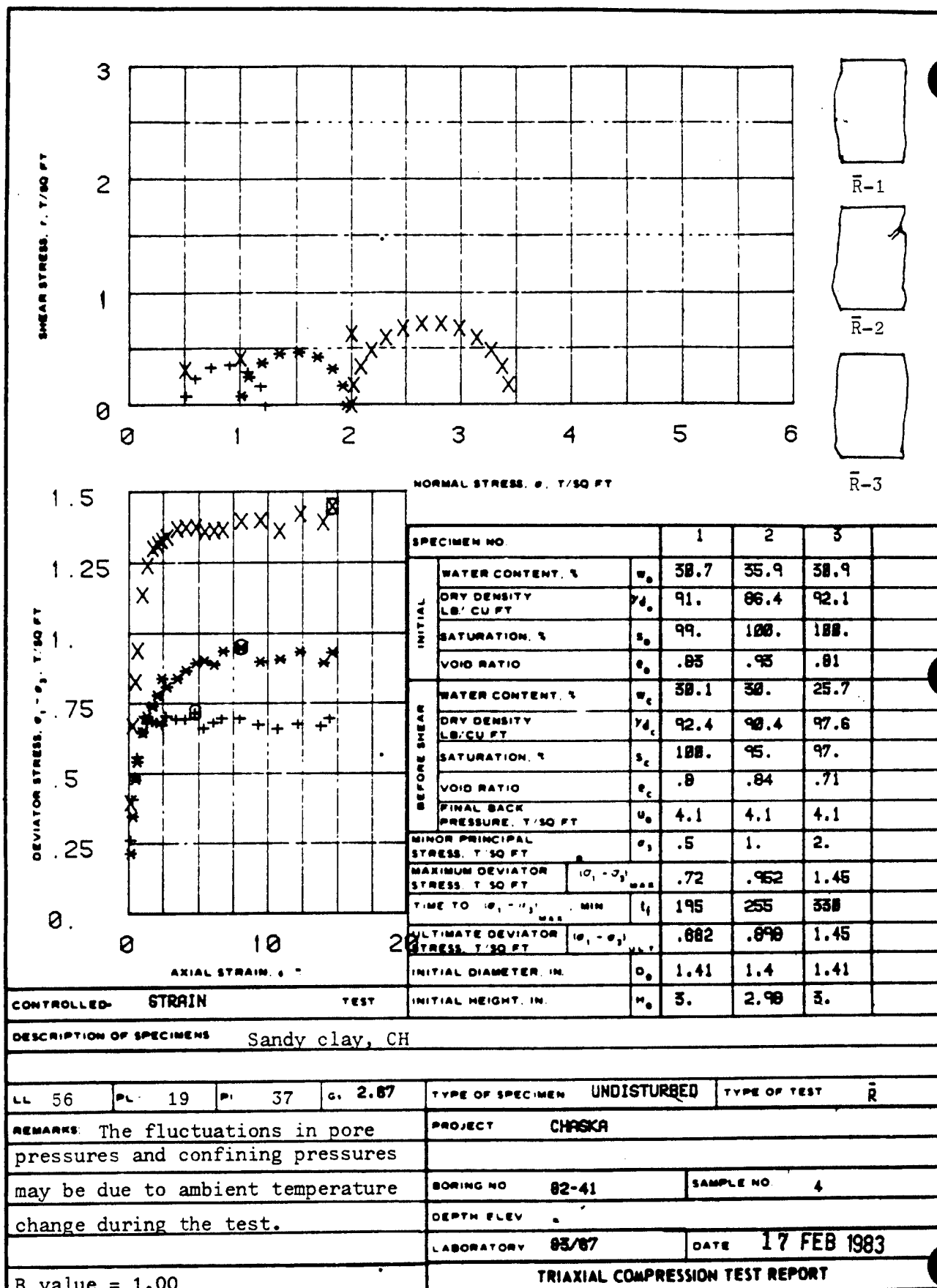
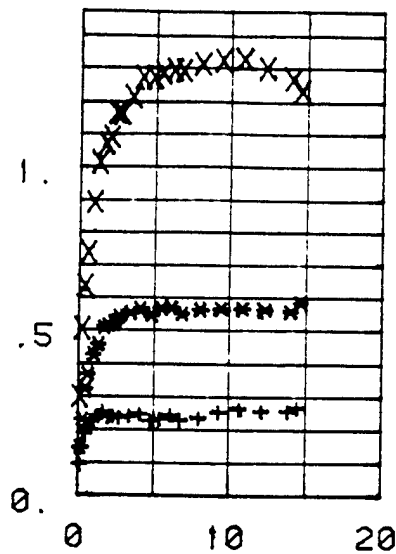


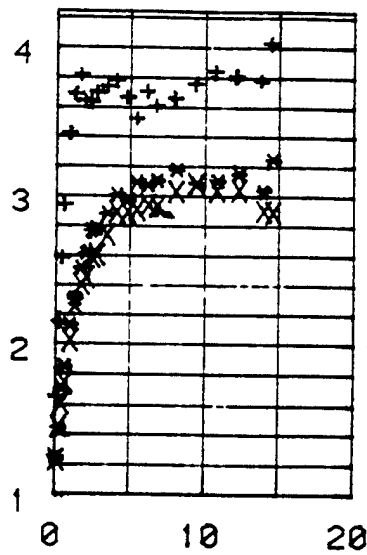
Figure 21



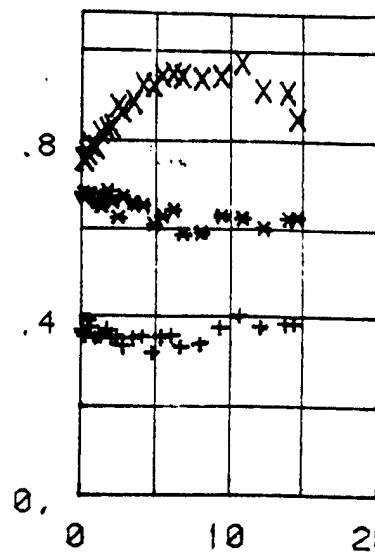
PORE PRESSURE, TSF



PRINCIPAL STRESS RATIO



PORE PRESSURE/DEVIATOR STRESS



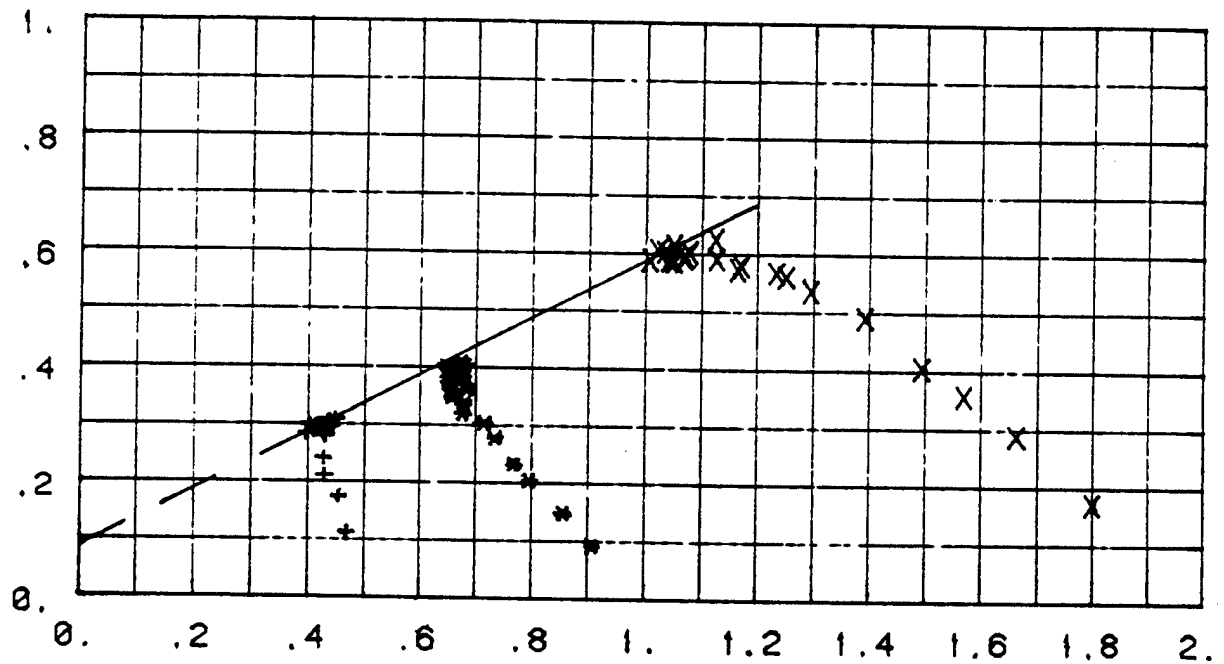
STRAIN, %

STRAIN, %

STRAIN, %

EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE

SHEAR STRESS, TSF



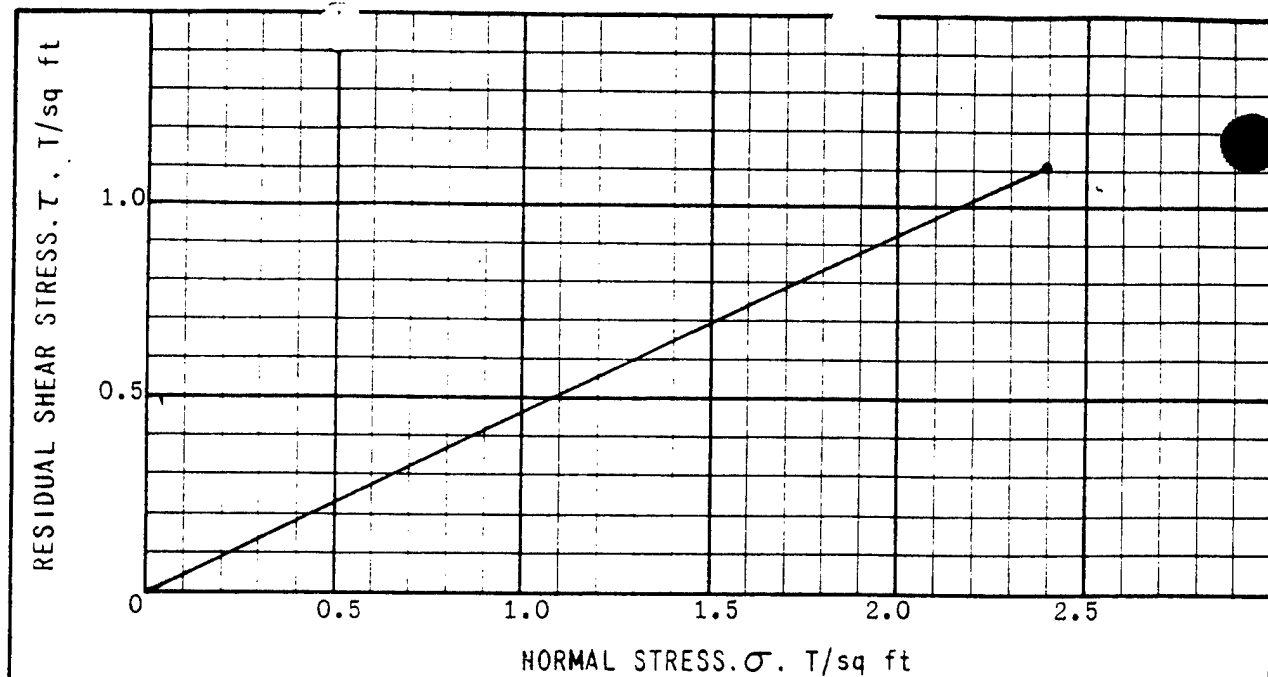
NORMAL STRESS, TSF

REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
R TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA  
BORING NO: 82-41 SAMPLE NO: 4  
DEPTH/ELEV: MRD LAB NO: 83/87 DATE: 17 FEB 1983

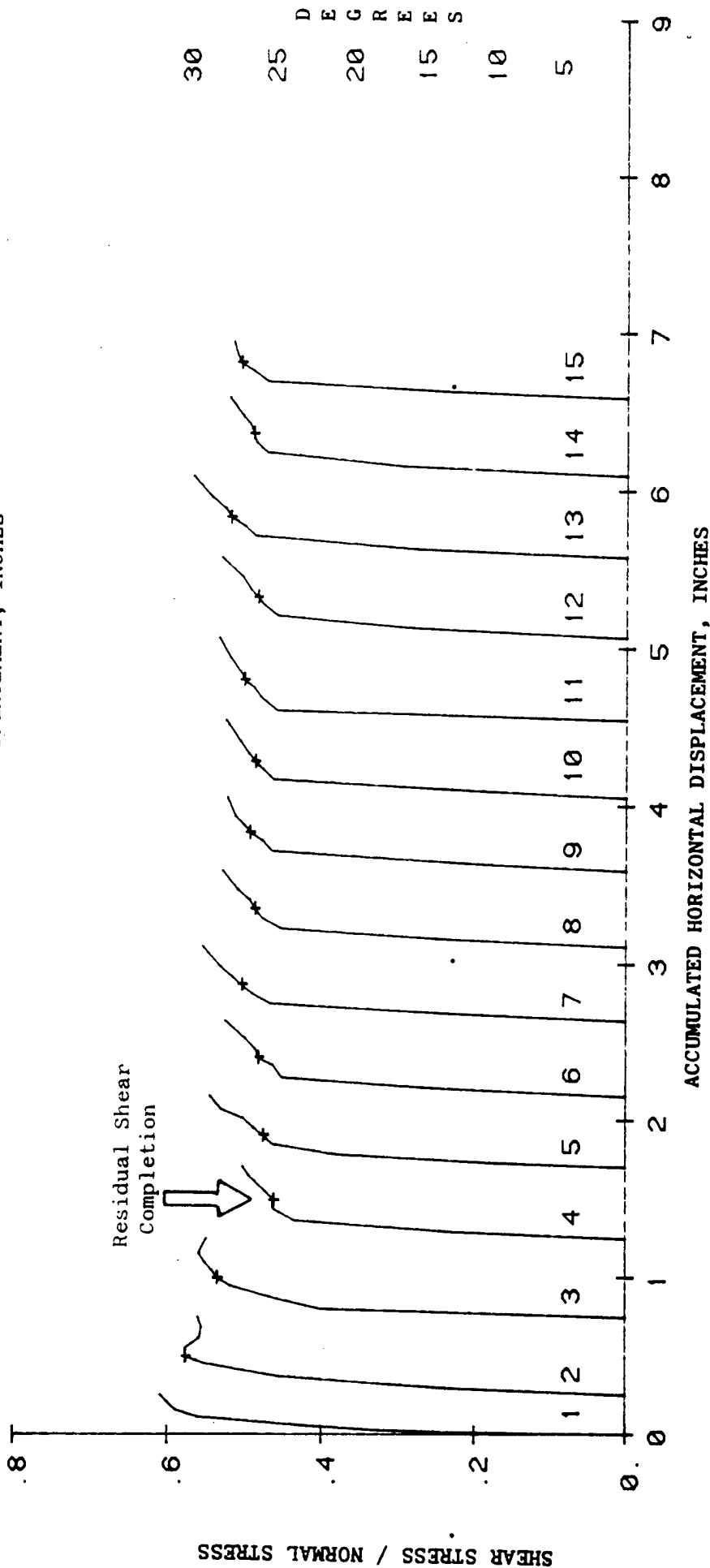
TRIAXIAL COMPRESSION TEST REPORT

FIGURE: 23



TEST NO.		1		RESIDUAL SHEAR STRESS. T/sq ft		1.11	
INITIAL	WATER CONTENT	$w_o$	35.4	$\tau/\sigma$ AT RESIDUAL		0.46	
	VOID RATIO	$e_o$	0.97	TIME TO RESIDUAL, days		5.9	
	SATURATION	$S_o$	97.5	DISPLACEMENT TO RESIDUAL, inches		1.46	
	DRY DENSITY, lb/cu ft	$d$	84.6	FINAL SHEAR STRESS, T/sq ft		1.23	
SPECIFIC GRAVITY		$G_s$	2.67	FINAL DISPLACEMENT, inches		6.78	
LIQUID LIMIT		LL	56	LENGTH OF TEST, days		20.7	
PLASTIC LIMIT		PL	19	MATERIAL EXTRUDED, gms		2.7	
WATER CONTENT		$w_f$	25.1	MATERIAL EXTRUDED.		1.4	
NORMAL STRESS, T/sq ft		$\sigma$	2.4	SHEAR STRENGTH PARAMETERS	$\phi$ MAXIMUM	-	
MAXIMUM SHEAR STRESS, T/sq ft		$\tau_{max}$	-		$\phi$ RESIDUAL	24.7*	
DISPLACEMENT TO MAXIMUM, inches		-	-		COHESION T/sq ft	0	
SPECIMEN DIMENSIONS 3.0 IN. SQUARE 0.5 IN. THICK				MISSOURI RIVER DIVISION LABORATORY, OMAHA, NEBRASKA			
CONTROLLED <input checked="" type="checkbox"/> STRAIN <input type="checkbox"/> STRESS				PROJECT Chaska		LAB. NO. 83/67	
TYPE OF SPECIMEN Undisturbed, precut				AREA			
CLASSIFICATION Sandy clay, CH				BORING NO. <sup>52</sup> 83-41		SAMPLE NO. 4	
*The residual shear test is normally used on hard shales and may not be meaningful on this material.				DEPTH ELEVATION		DATE 17 FEB 1983	
				RESIDUAL DIRECT SHEAR TEST REPORT			

SHEAR STRESS/NORMAL STRESS  
VS.  
ACCUMULATED HORIZONTAL DISPLACEMENT, INCHES



PULL NO: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15  
IN./DAY: .27 .49 .43 .15 .47 .46 .47 .54 .16 .53 .56 .52 .17 .42

SPECIMEN TYPE: UNDISTURBED, PRECUT

NORMAL STRESS, T/SF: 2.4

REMARKS:

PROJECT: CHASKA

BORING NO: 82-41

SAMPLE NO: 4

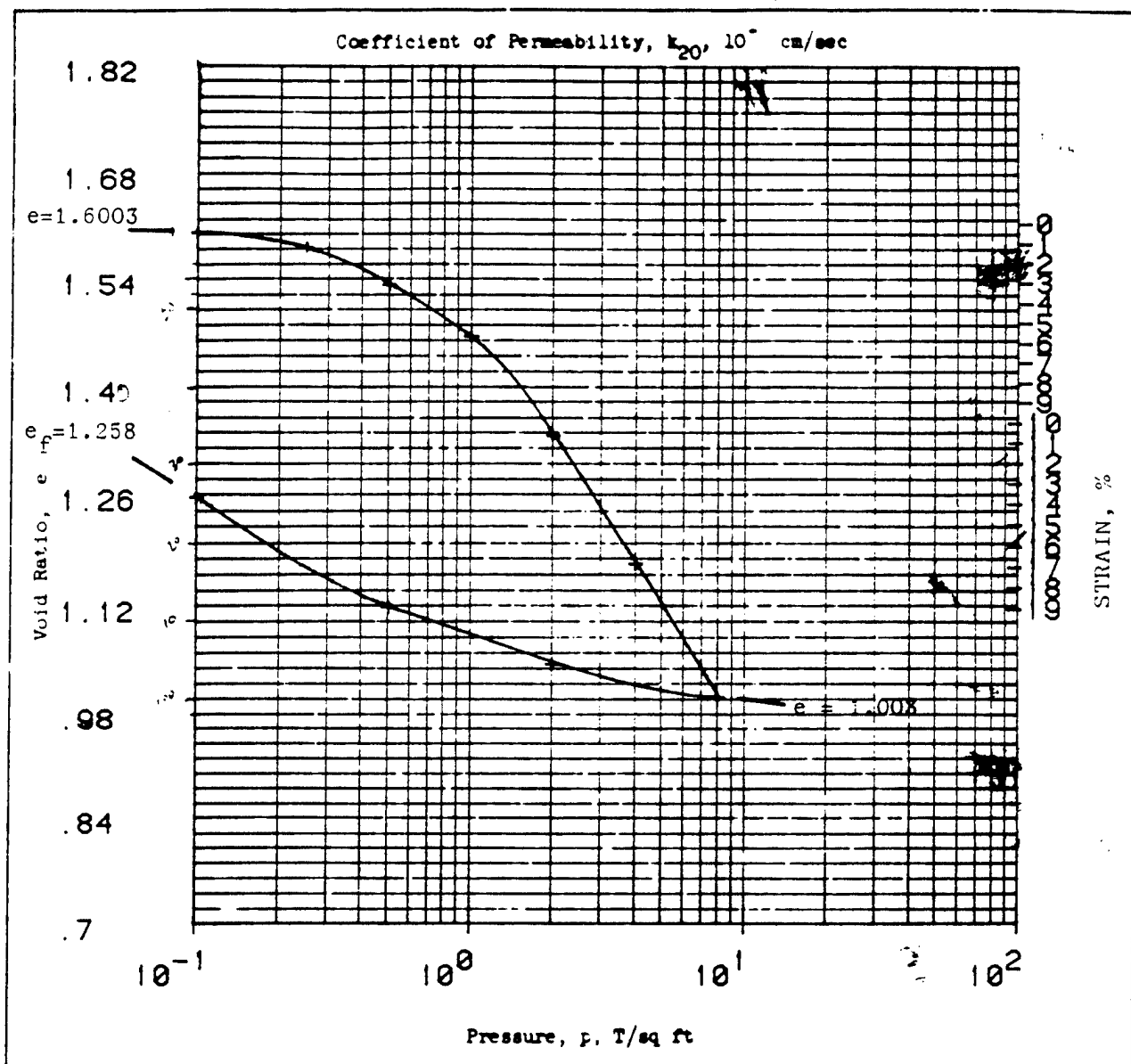
DEPTH:

MRD LAB NO: 83/87

DATE: 17 FEB 1983

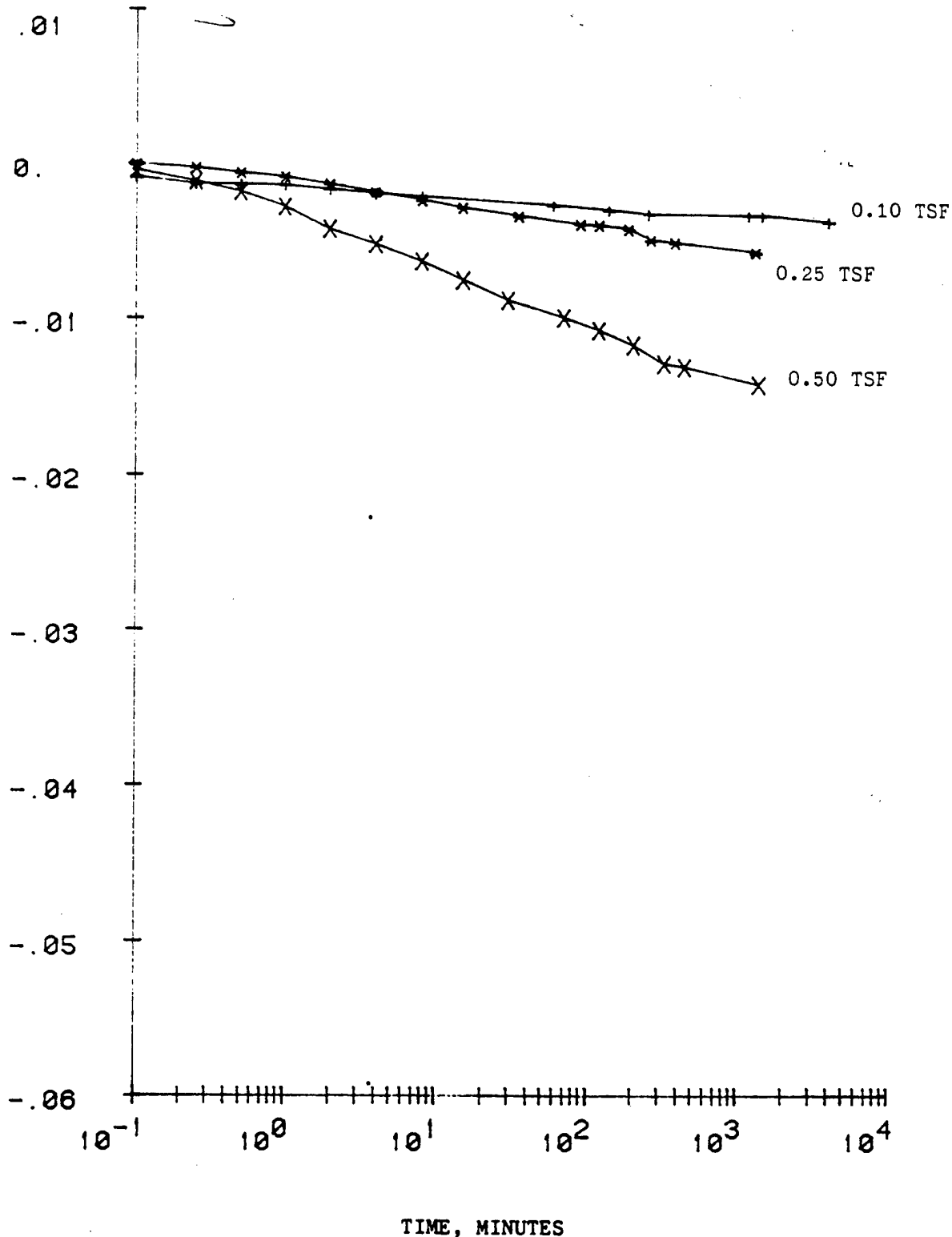
RESIDUAL DIRECT SHEAR TEST REPORT

FIGURE: 25



Type of Specimen <b>UNDISTURBED</b>		Before Test		After Test	
Diam <b>2.5</b> in.	Ht <b>.749</b> in.	Water Content, $w_o$	<b>68.</b> %	$w_f$	<b>48.7</b> %
Overburden Pressure, $p_o$ T/sq ft		Void Ratio, $e_o$	<b>1.62</b>	$e_f$	<b>1.26</b>
Preconsol. Pressure, $p_c$ T/sq ft		Saturation, $S_o$	<b>100.</b> %	$S_f$	<b>97.</b> %
Compression Index, $C_c$		Dry Density, $\gamma_d$	<b>59.9</b> lb/ft <sup>3</sup>		
Classification Organic Fat clay, CH		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL <b>116</b>	$G_s$ <b>2.51</b>	Project <b>CHASKA NCS-IA-82-126-ED-6H</b>			
PL <b>31</b>	$D_{10}$				
Remarks		Area <b>MRD LAB NO: 83/67</b>			
		Boring No. <b>82-51</b>	Sample No. <b>1</b>		
		Depth <b>28-30</b> ft	Date <b>7 APR 1983</b>		
		<b>CONSOLIDATION TEST REPORT</b>			

DEFORMATION, INCHES



PROJECT: CHASKA NCS-IA-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 7 APR 1983

BORING NO: 82-51

SAMPLE NO: 1

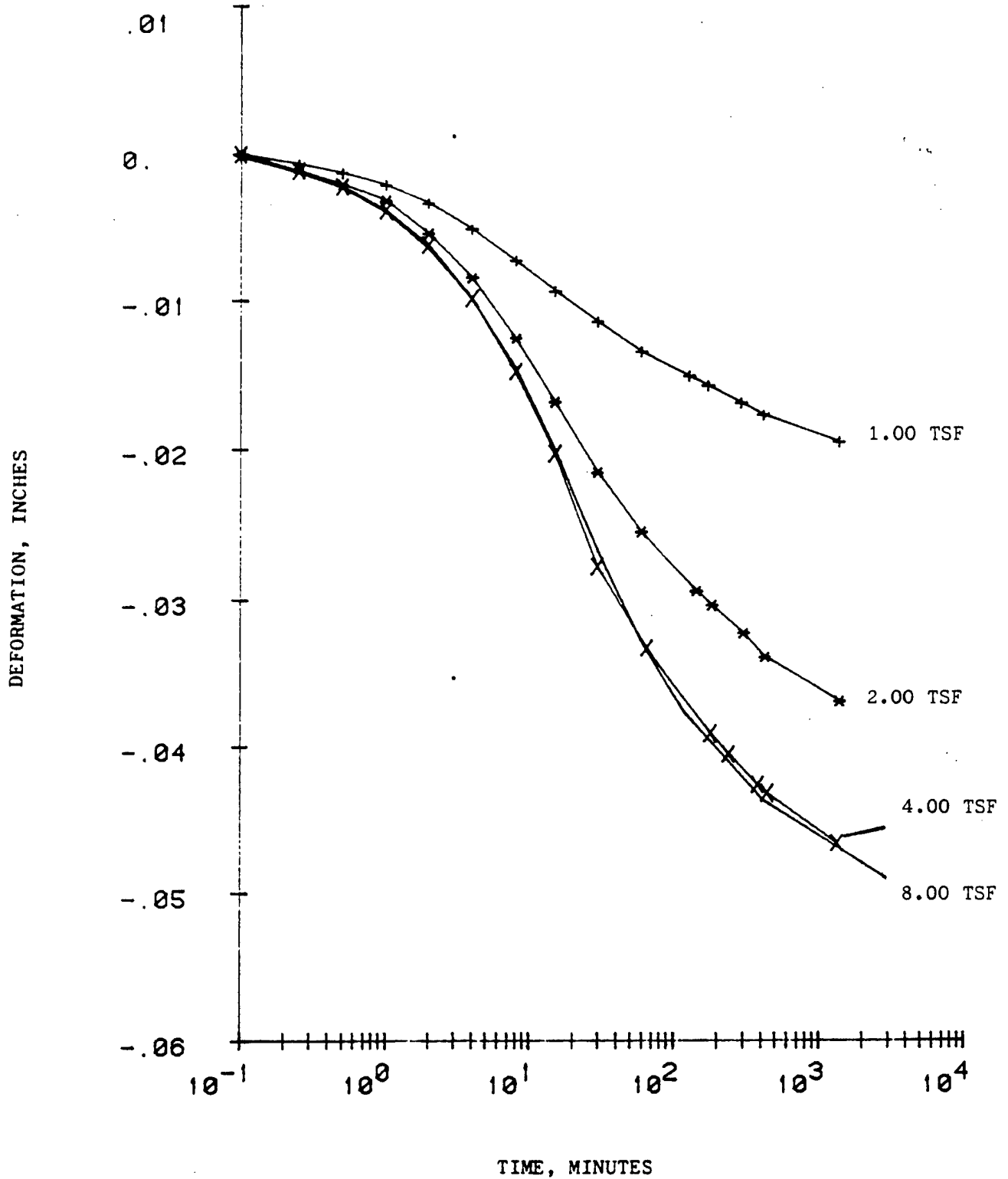
DEPTH/ELEV: 2.8-3.0

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 2

Figure C-75



PROJECT: CHASKA NCS-1A-82-126-ED-6H

MRD LAB NO: 83/67

BORING NO: 82-51

SAMPLE NO: 1

DATE: 7 APR 1983

DEPTH/ELEV: 2.8-3.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

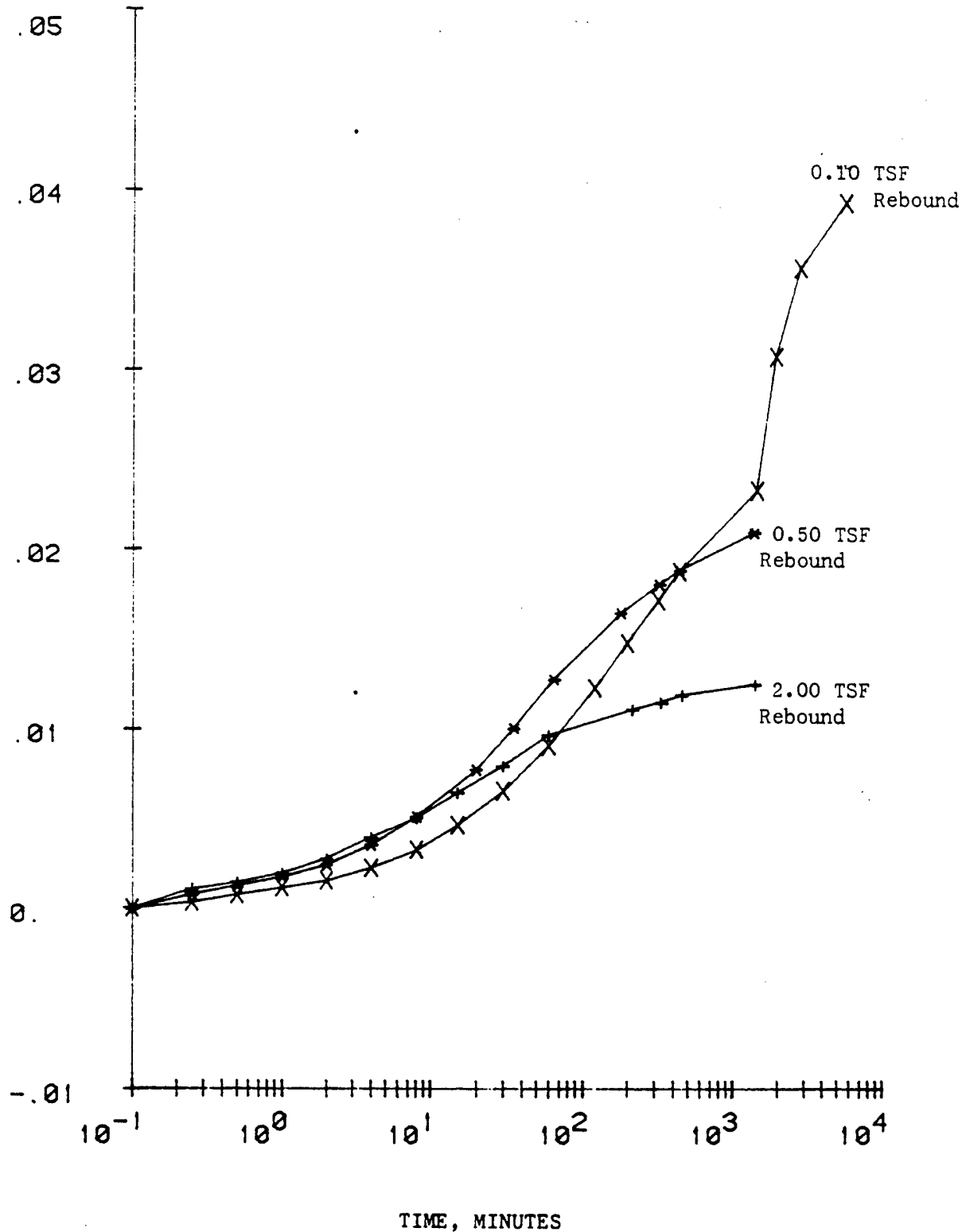
CONSOLIDATION TEST—TIME CURVES

FIGURE: 3

Figure C-76



DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-82-126-ED-GH

MRD LAB NO: 83/67

DATE: 7 APR 1983

BORING NO: 82-51

SAMPLE NO: 1

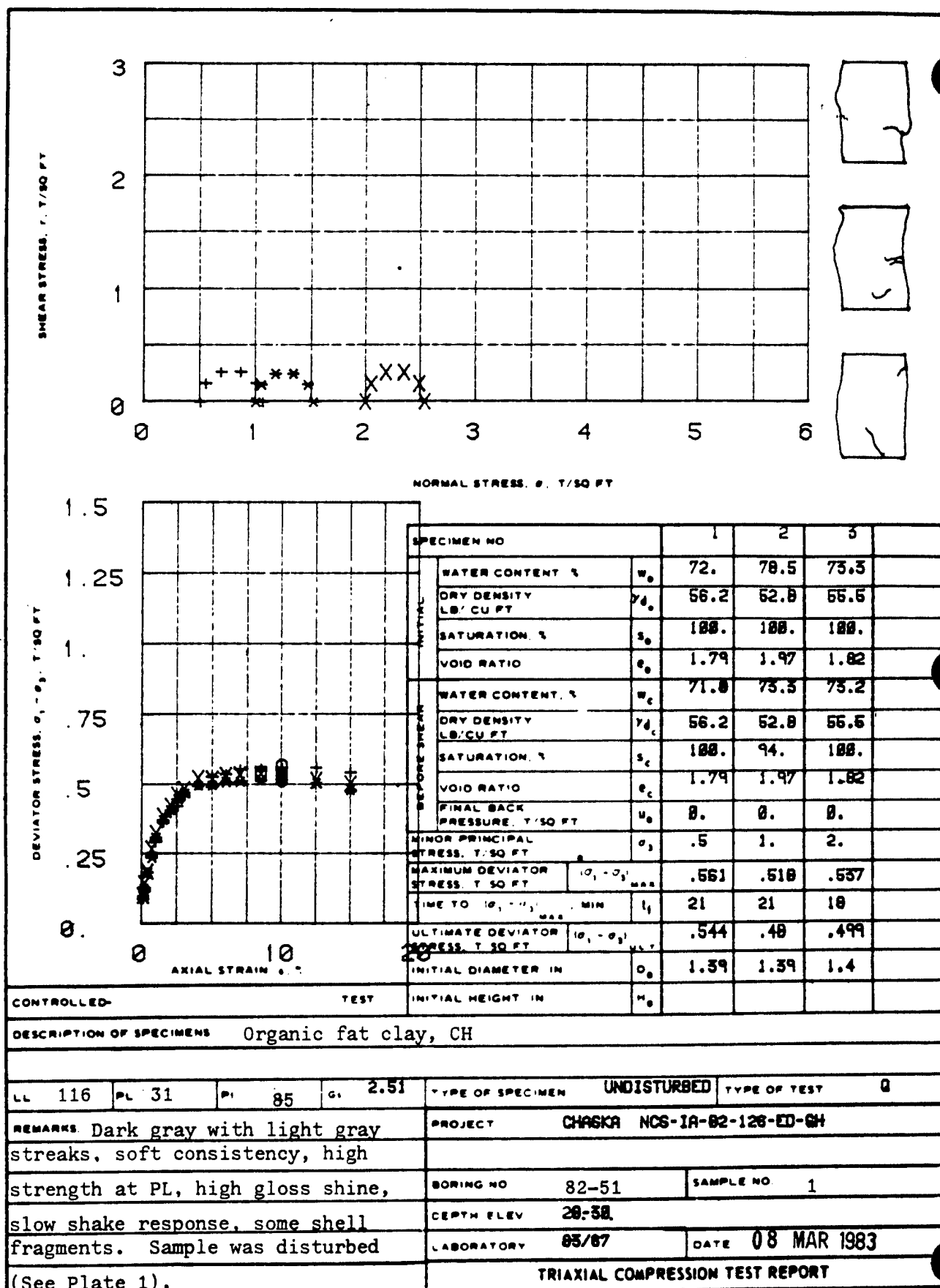
DEPTH/ELEV: 2.8-3.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST--TIME CURVES

FIGURE: 4

Figure C-77



ENG FORM NO 2089 PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

Shear strengths may represent remolded strengths.

Figure 17

Figure C-78

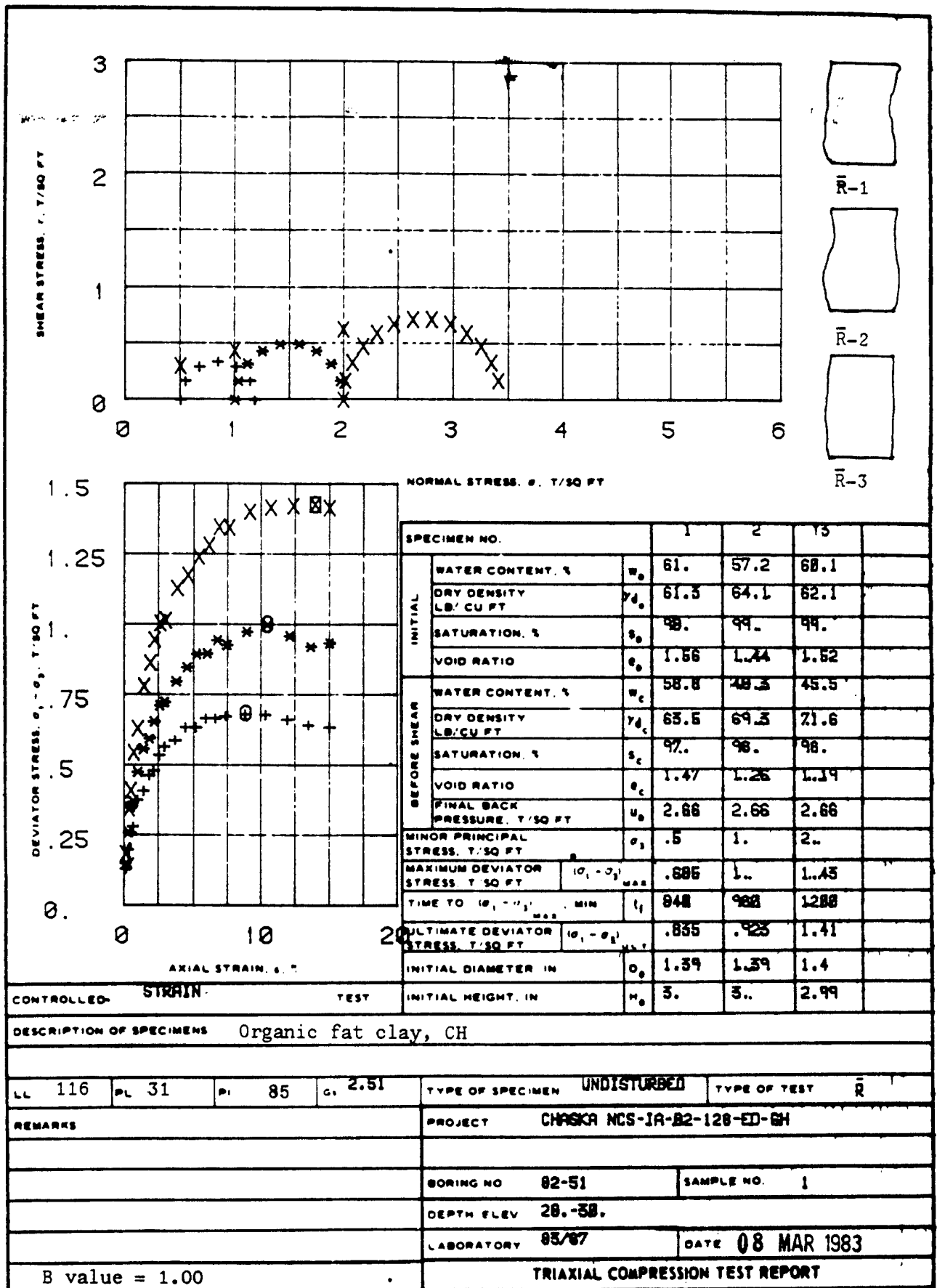
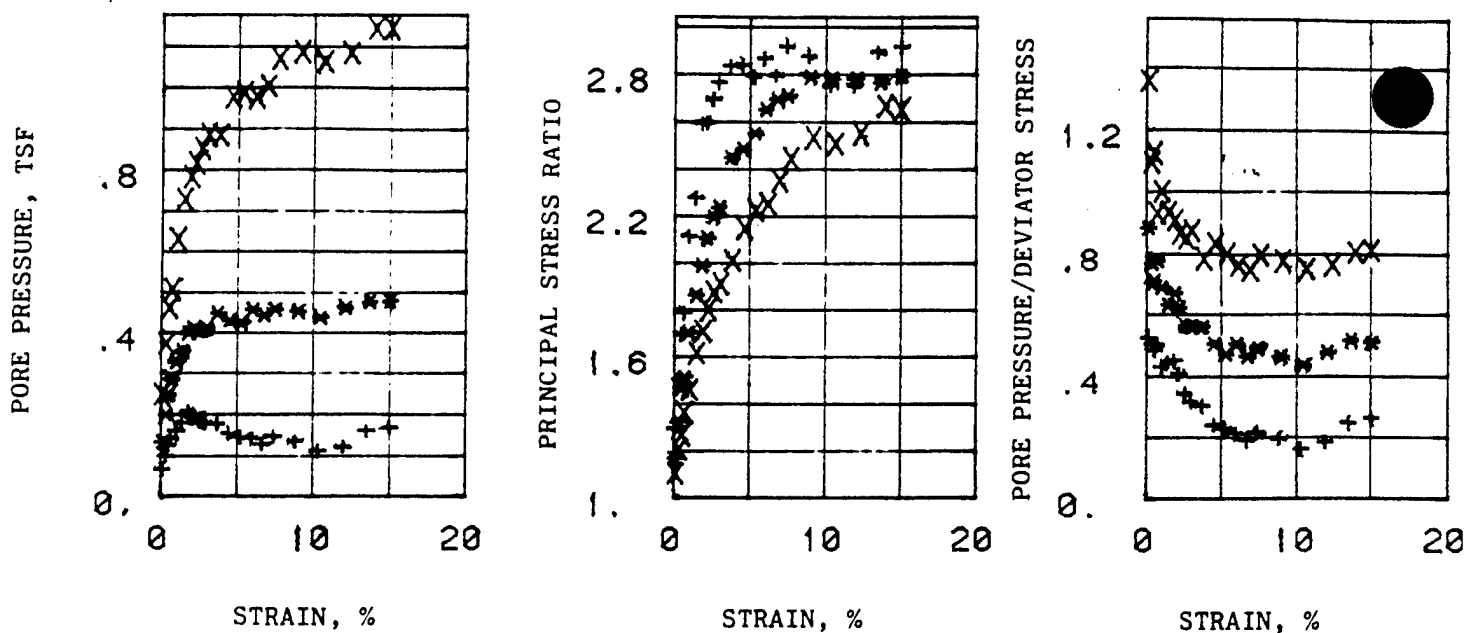
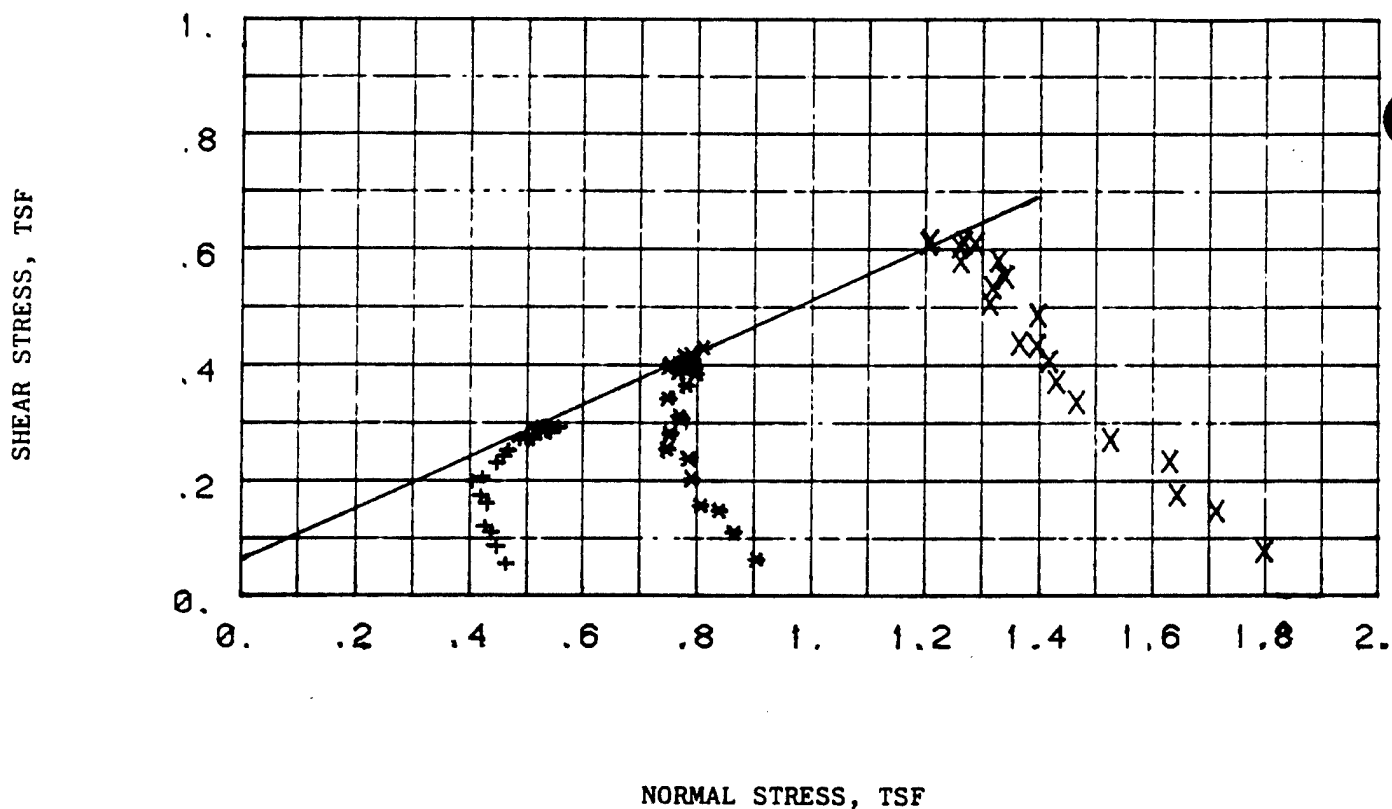


Figure 18

Figure C-79



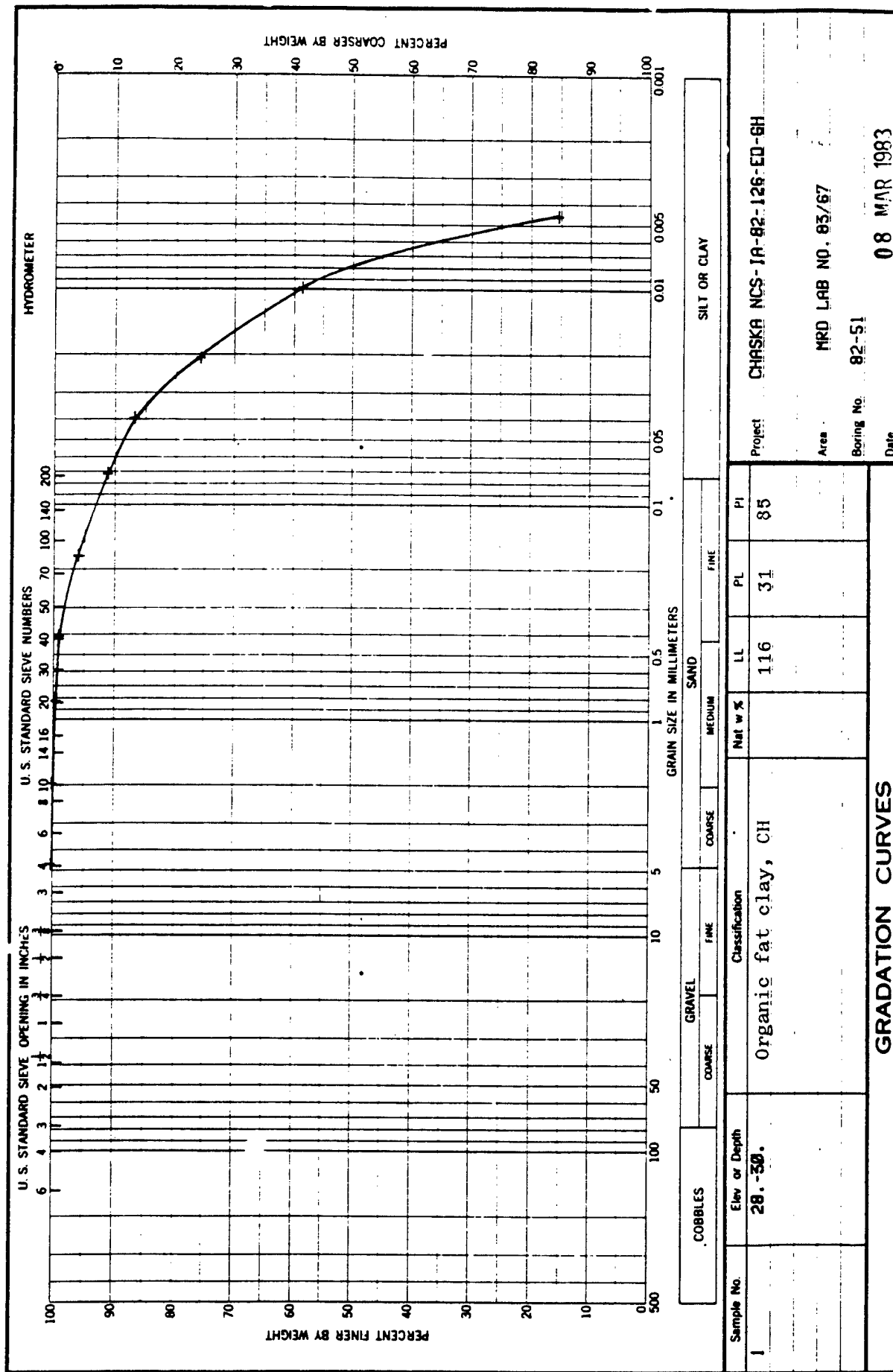
EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



REMARKS: COMPUTER PRINT-OUT  
 SYMBOLS SAME AS FORM 2089  
 TRIAXIAL TEST: PORE PRESSURE  
 MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-82-126-ED-BH  
 BORING NO: 82-51 SAMPLE NO: 1  
 DEPTH/ELEV: 20.-38.  
 MRD LAB NO: 85/67 DATE: 08 MAR 1983

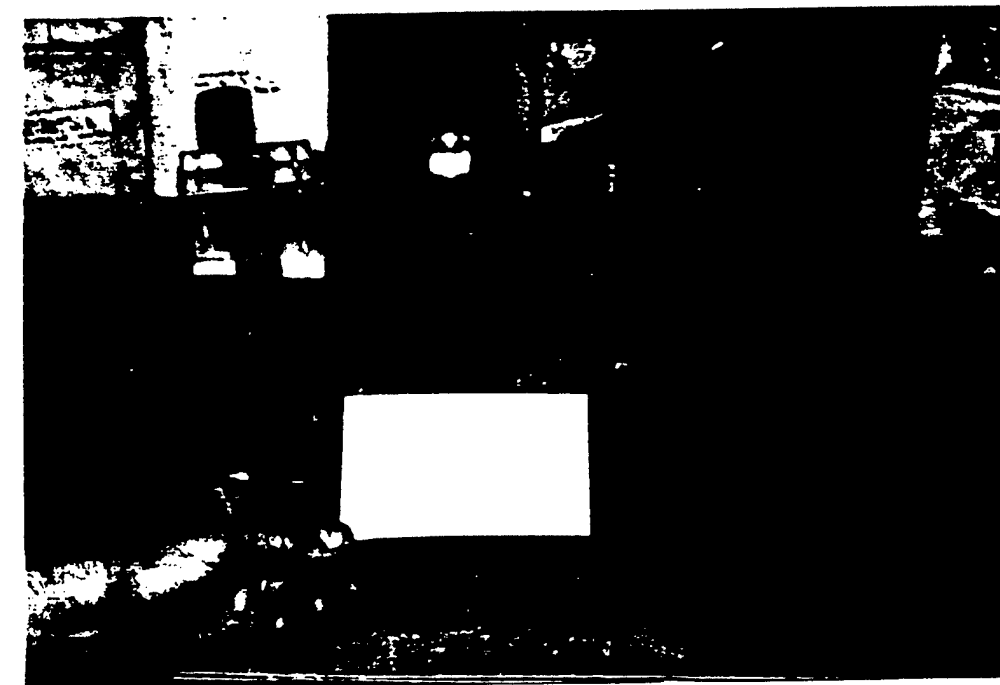
TRIAXIAL COMPRESSION TEST REPORT



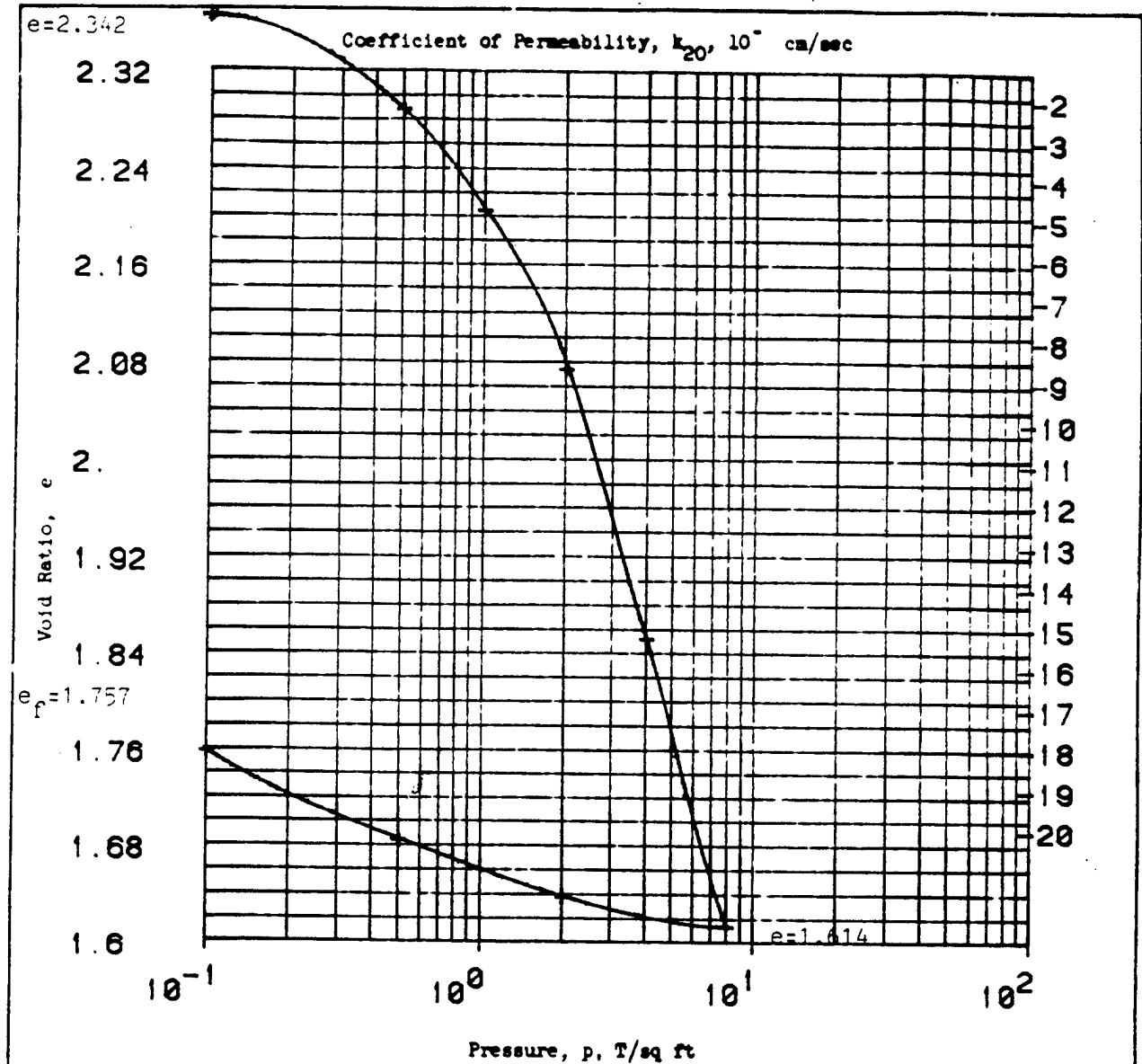
ENG FORM 2087  
1 MAY 63

FIGURE 20

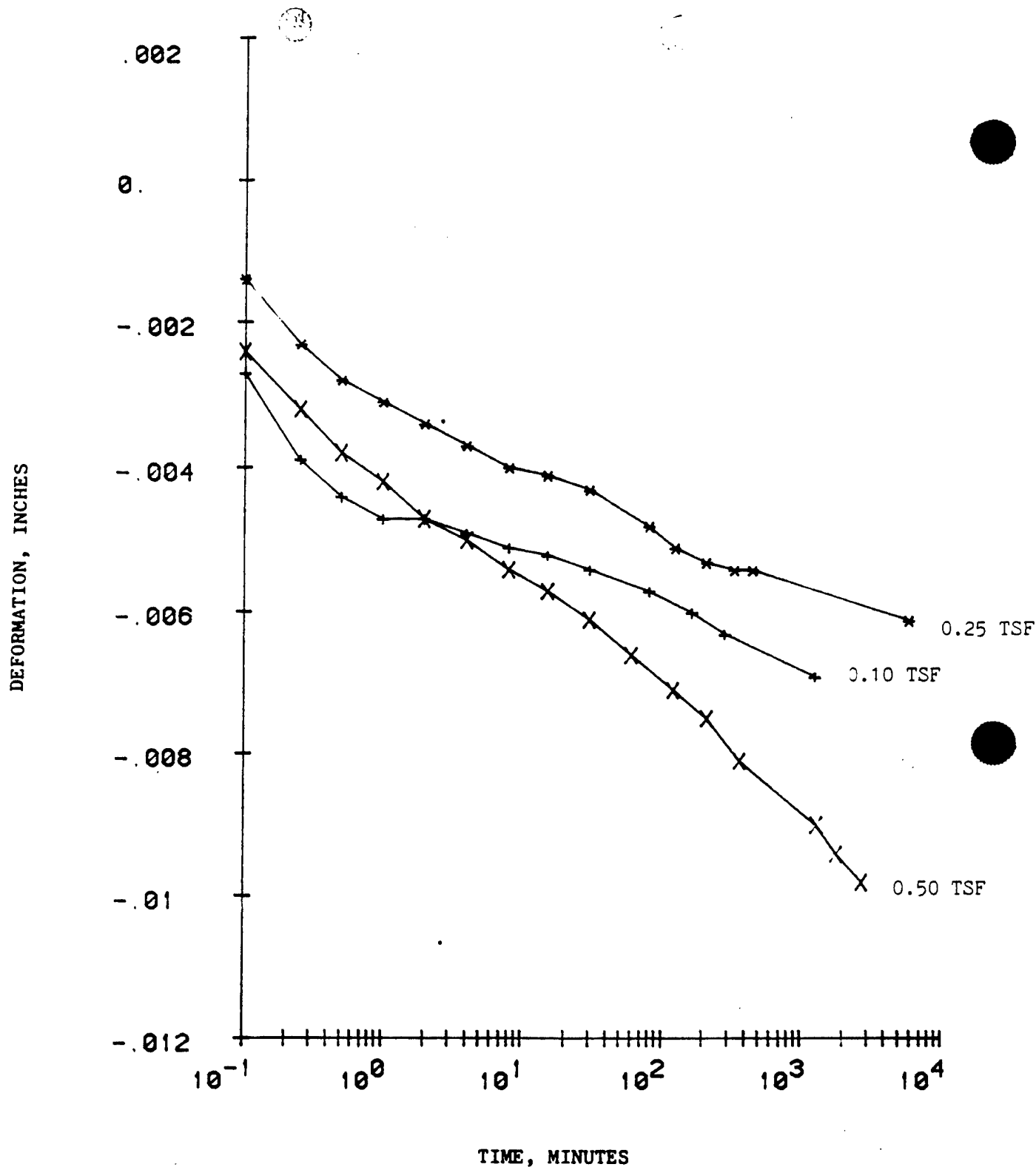
Figure C-81



Disturbed Boring 82-51 Sample 1.



Type of Specimen <b>UNDIST</b>				Before Test		After Test			
Diam	4.29	in.	Ht	1.	in.	Water Content, $w_o$	82.8 %	$w_f$	61.3 %
Overburden Pressure, $p_o$				T/sq ft		Void Ratio, $e_o$	2.37	$e_f$	1.76
Preconsol. Pressure, $p_c$				T/sq ft		Saturation, $S_o$	95. %	$S_f$	95. %
Compression Index, $C_c$						Dry Density, $\gamma_d$	58.2 lb/ft <sup>3</sup>		
Classification Clayey silt, MH				$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec					
LL	81	$G_s$	2.71	Project <b>CHASKA</b>					
PL	37	$D_{10}$							
Remarks				Area <b>MRO LAB NO: 84/34</b>					
				Boring No. <b>83-53 MU</b>			Sample No. <b>S-1</b>		
				Depth <b>17.8-19.8</b>			Date <b>27 DEC 1983</b>		
				<b>CONSOLIDATION TEST REPORT</b>					



PROJECT: CHASKA

MRD LAB NO: 84/34

BORING NO: 83-53 MU

SAMPLE NO: S-1

DATE: 27 DEC 1983

DEPTH/ELEV: 17.8-19.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

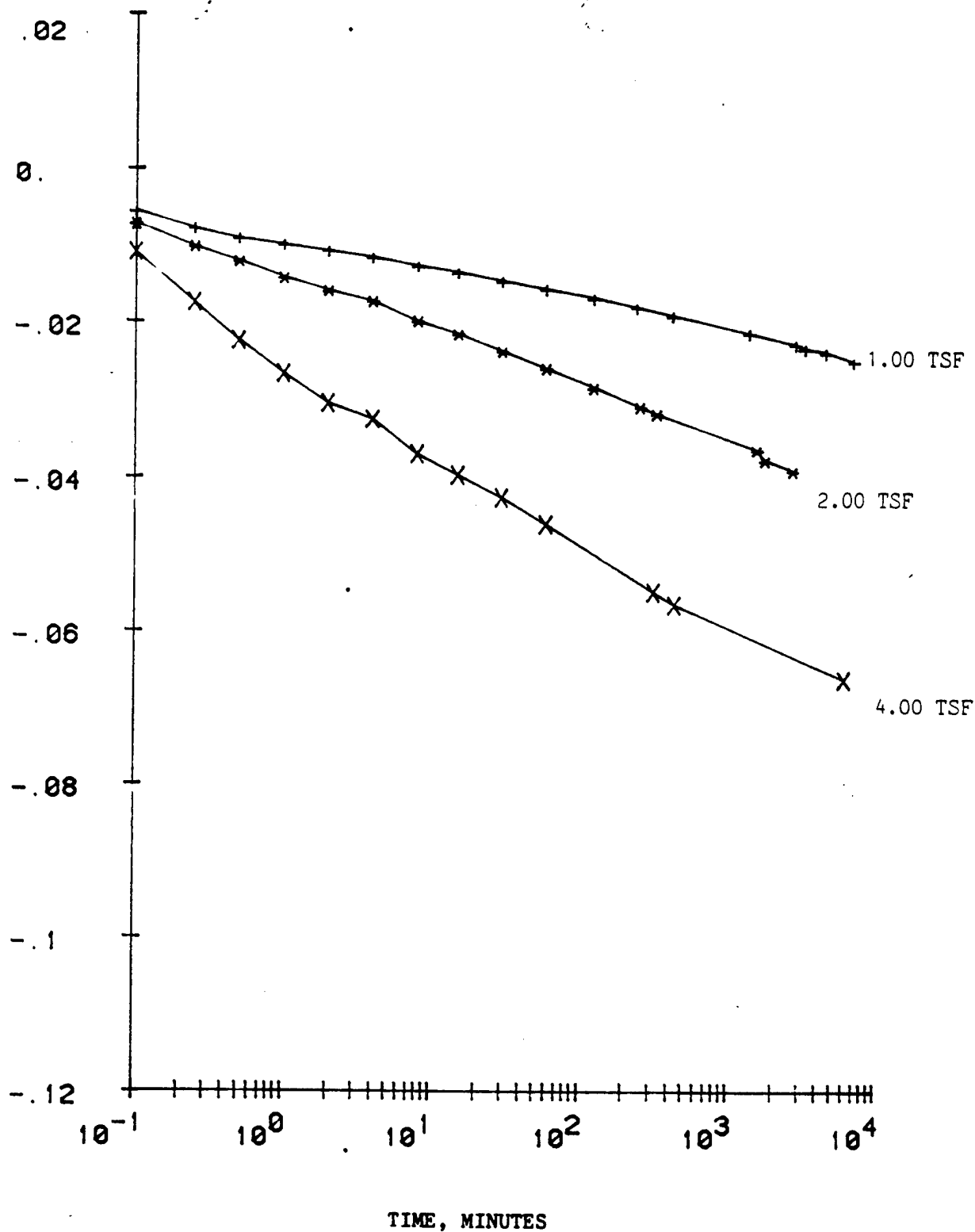
CONSOLIDATION TEST—TIME CURVES

FIGURE: 9

Figure C-84



DEFORMATION, INCHES



PROJECT: CHASKA

MRD LAB NO: 84/34

BORING NO: 83-53 MU

SAMPLE NO: S-1

DATE: 27 DEC 1983

DEPTH/ELEV: 17.8-19.8

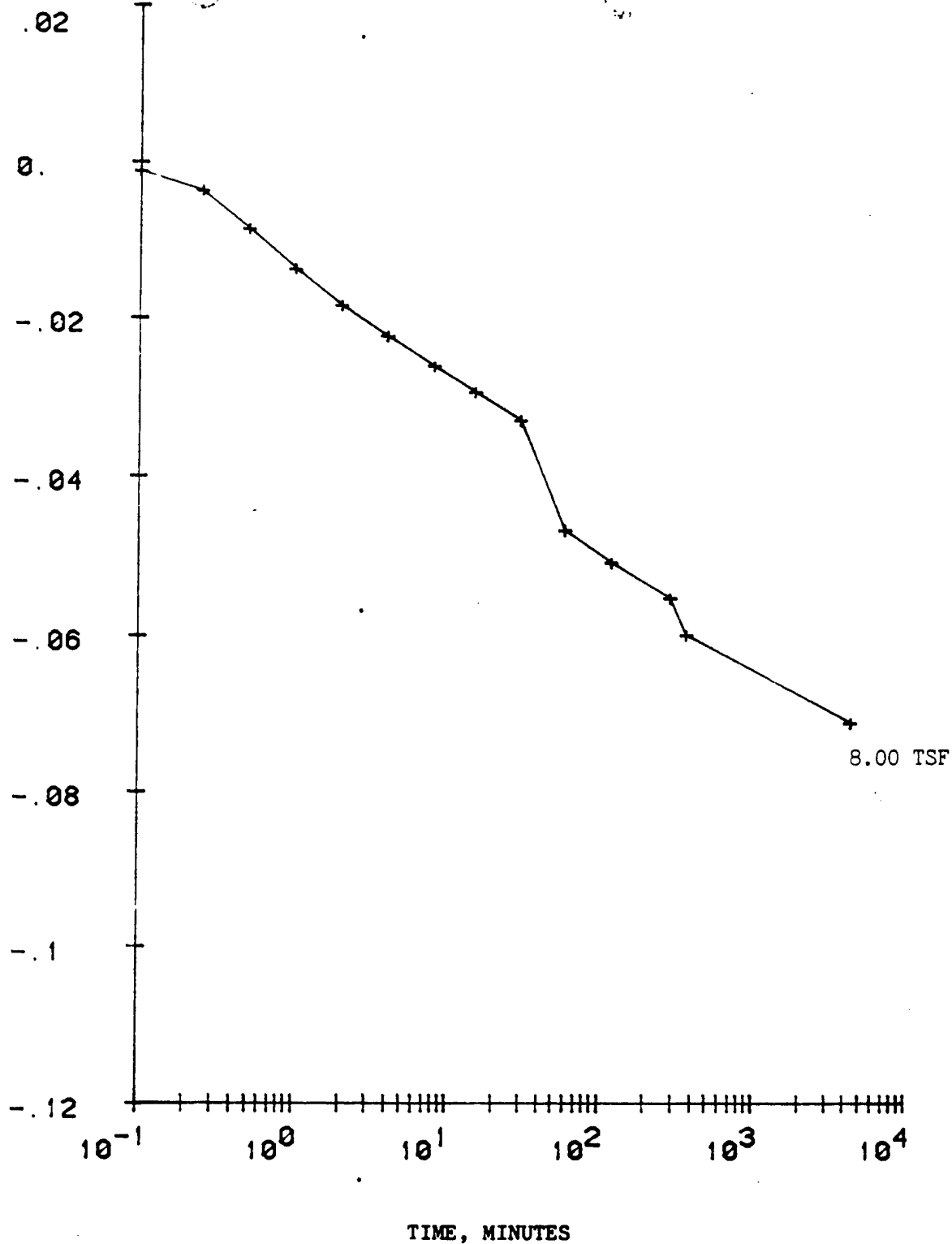
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 10

Figure C-85

DEFORMATION, INCHES



PROJECT: CHASKA

MRD LAB NO: 84/34

BORING NO: 85-53 MU

SAMPLE NO: S-1

DATE: 27 DEC 1983

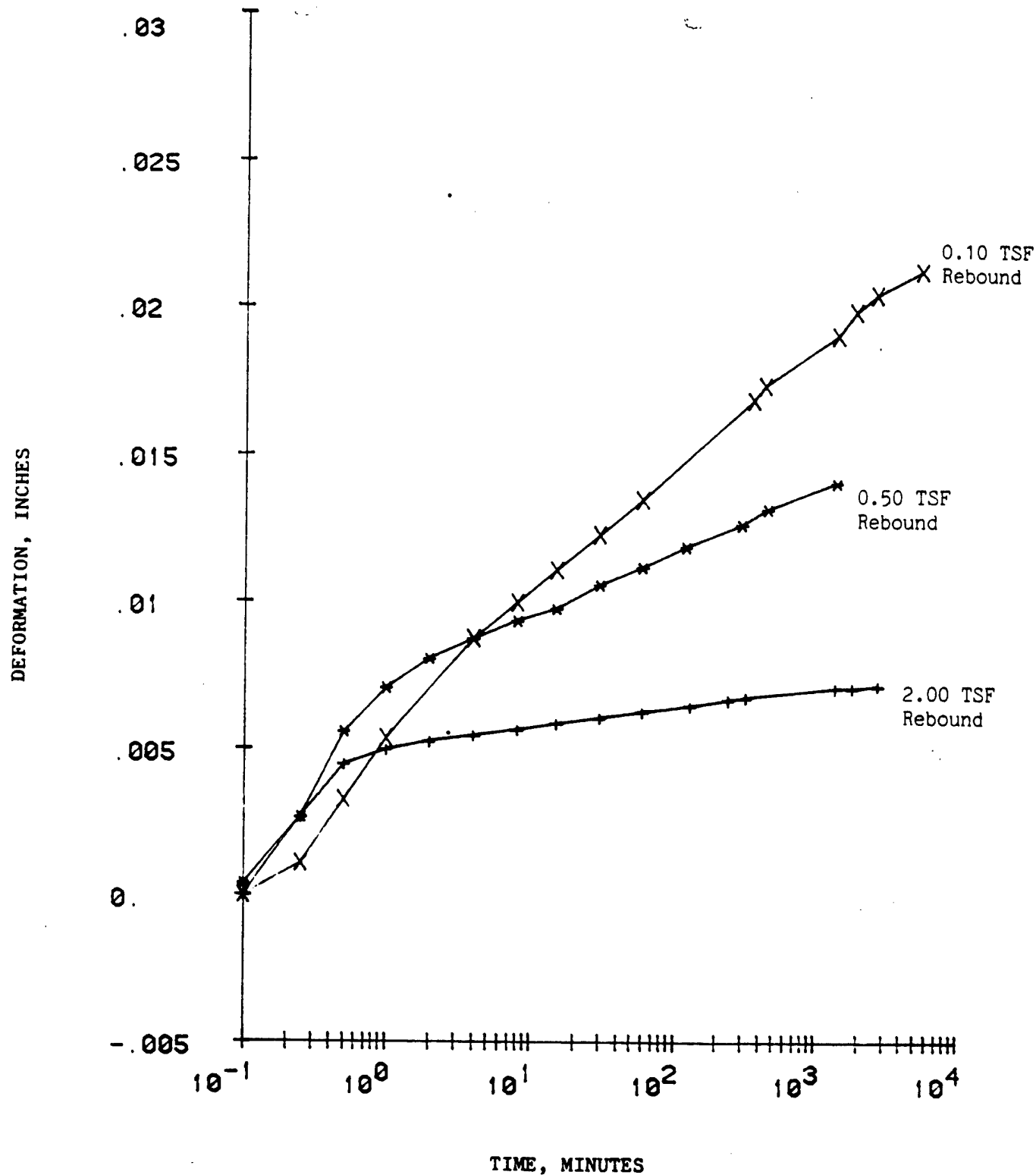
DEPTH/ELEV: 17.8-19.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 11

Figure C-86



PROJECT: CHASKA

MRD LAB NO: 84/34

BORING NO: 83-53 MU

SAMPLE NO: S-1

DATE: 27 DEC 1983

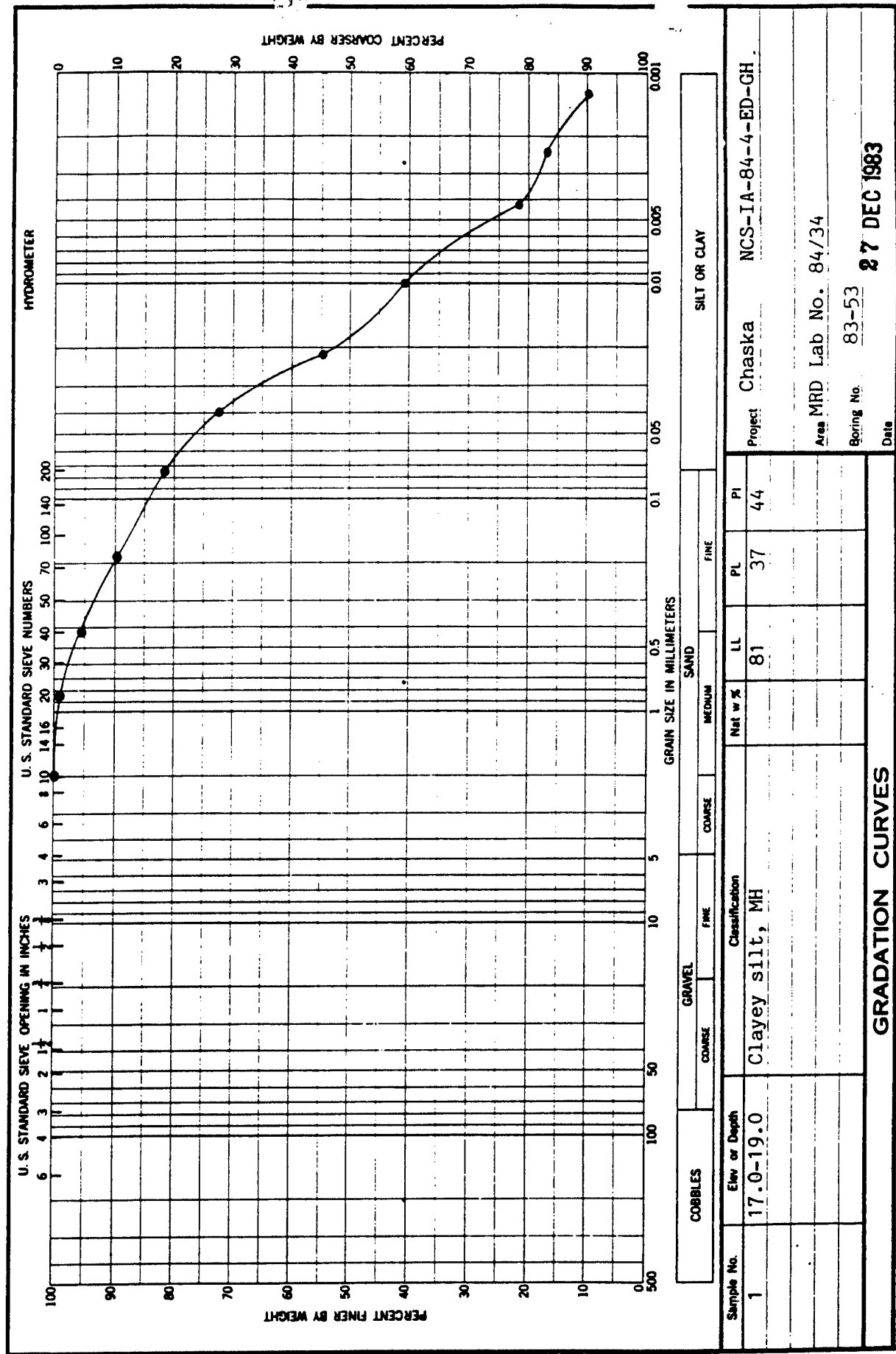
DEPTH/ELEV: 17.0-19.0

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 12

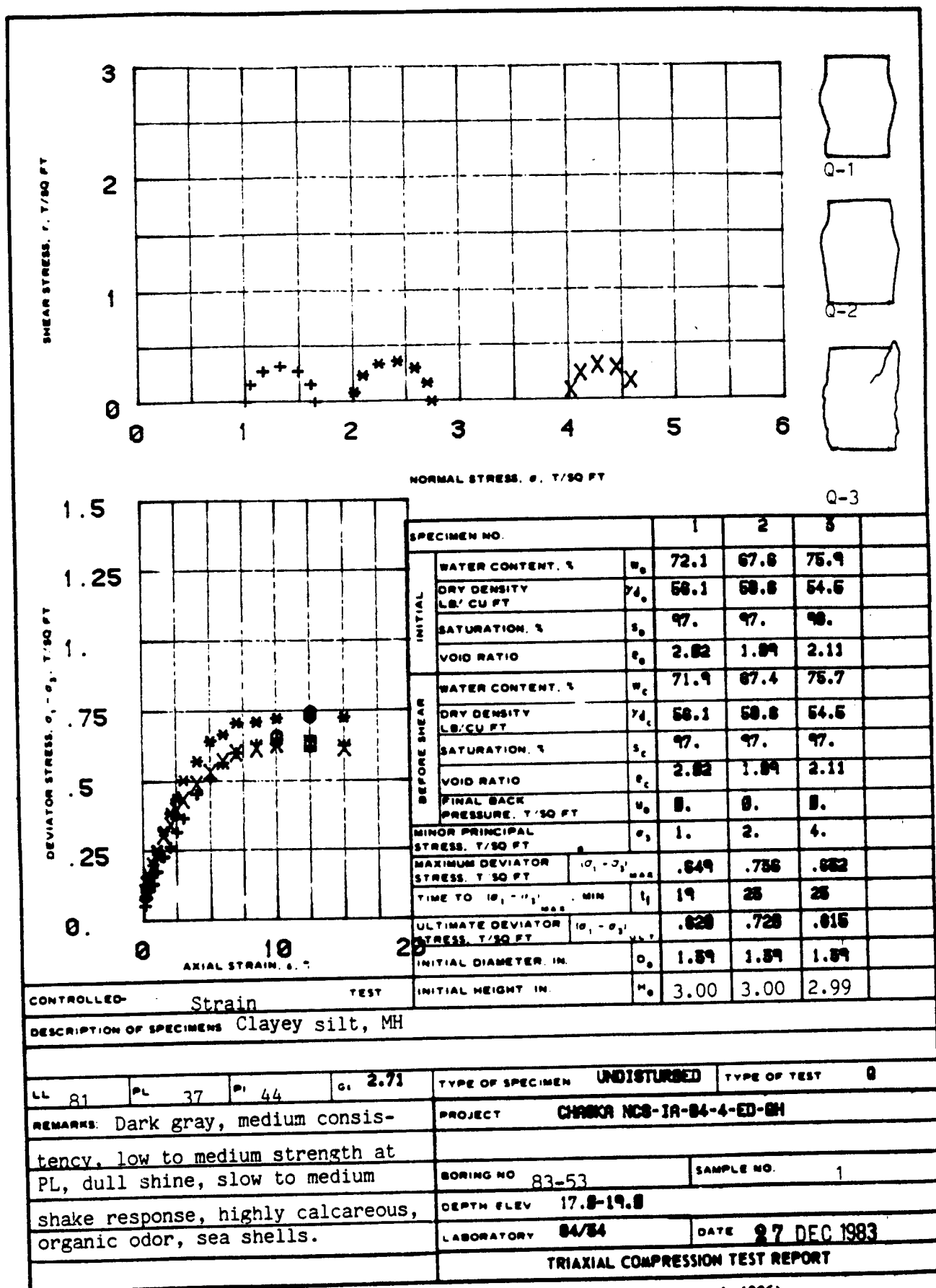
Figure C-87

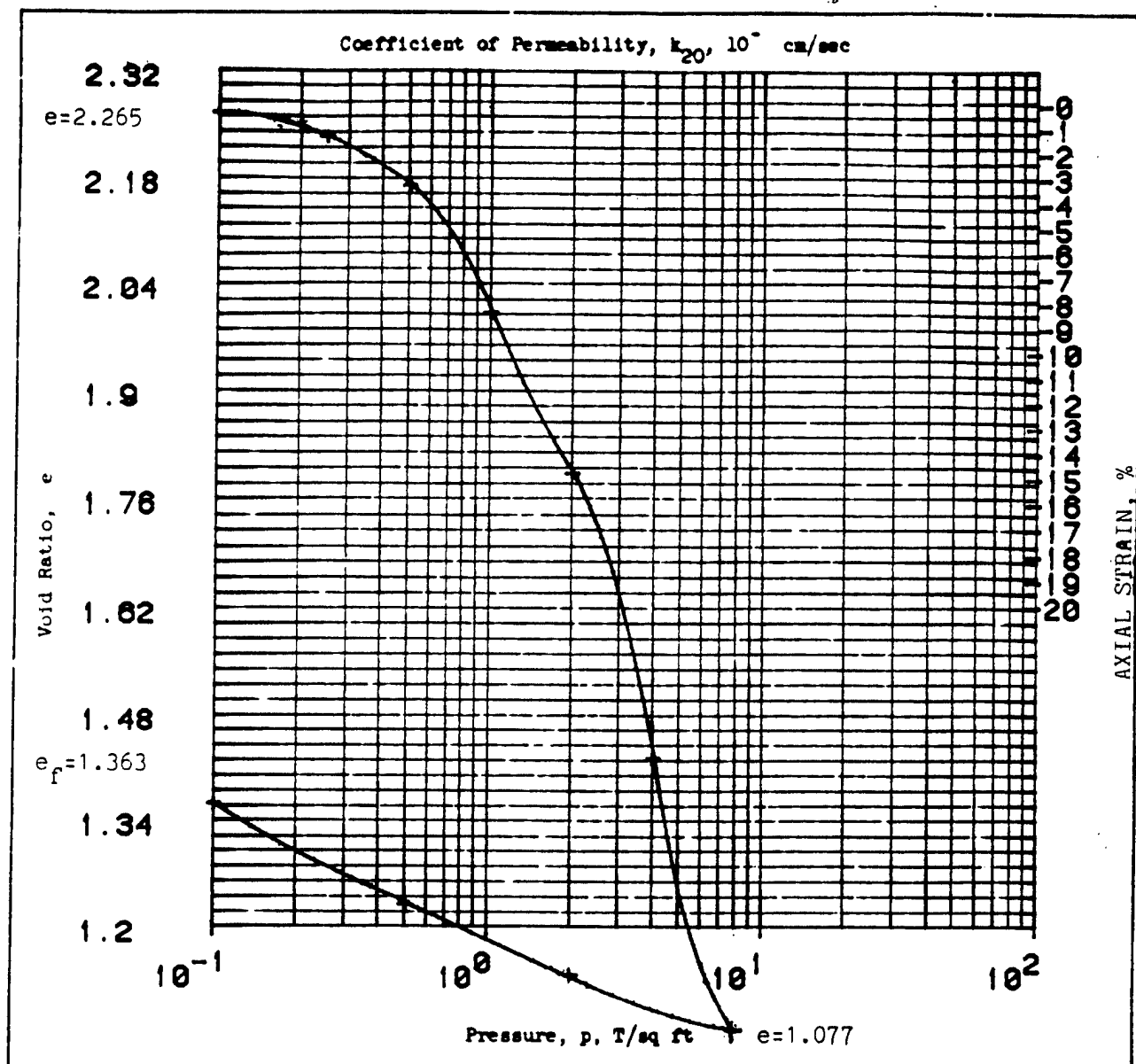


ENG FORM 1 MAY 83 2087

Figure 13

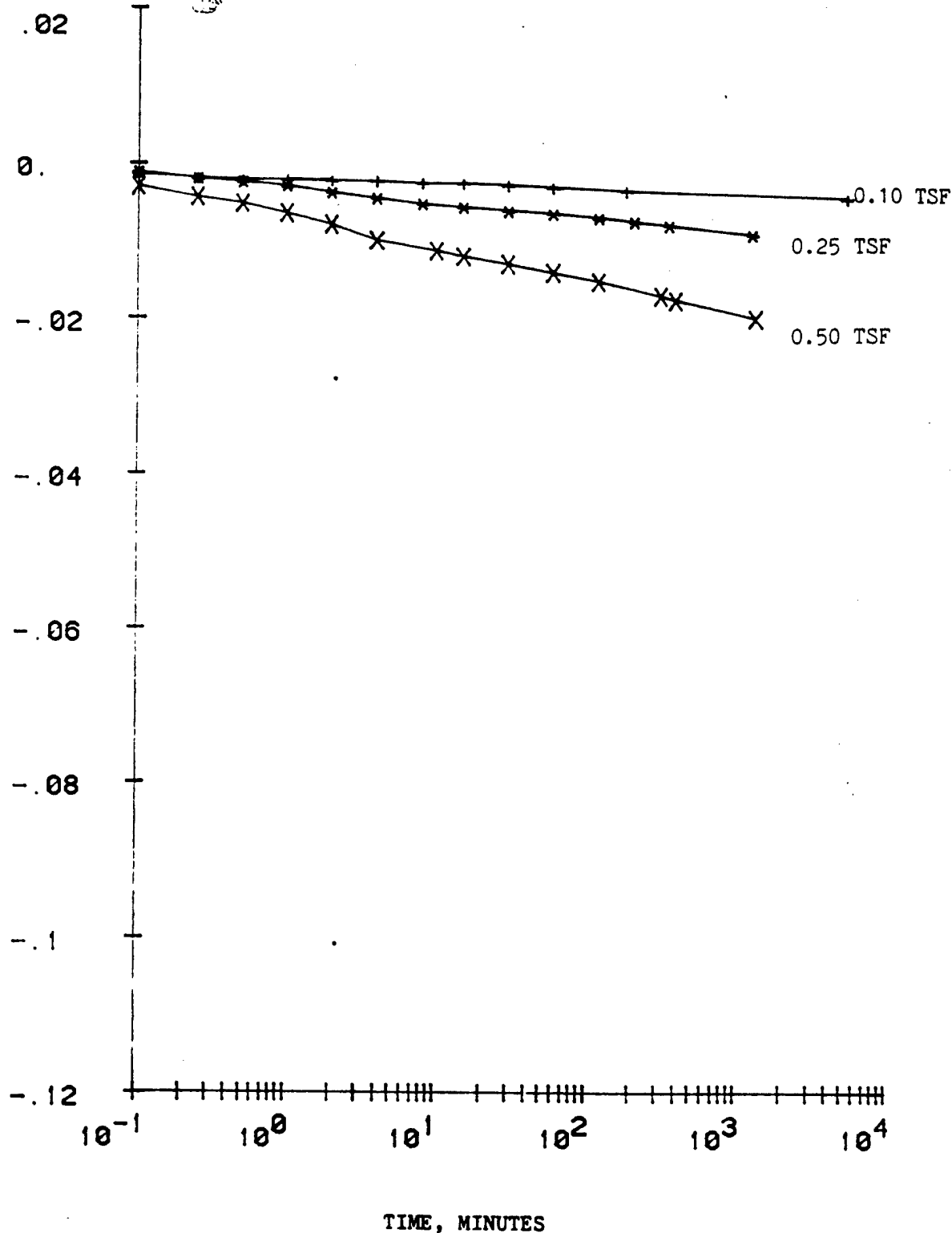
Figure C-88





Type of Specimen <b>UNDIST</b>		Before Test		After Test	
Diam <b>4.29</b> in.	Ht <b>1.</b> in.	Water Content, $w_o$	<b>73.7</b> %	$w_f$	<b>97.1</b> %
Overburden Pressure, $p_o$ T/sq ft		Void Ratio, $e_o$	<b>2.28</b>	$e_f$	<b>1.38</b>
Preconsol. Pressure, $p_c$ T/sq ft		Saturation, $S_o$	<b>78.</b> %	$S_f$	<b>100.</b> %
Compression Index, $C_c$		Dry Density, $\gamma_d$	<b>44.9</b> lb/ft <sup>3</sup>		
Classification <b>Sandy Organic, OH</b>		$k_{20}$ at $e_o$ = <b>          </b> $\times 10^{-7}$ cm/sec			
LL <b>207</b>	$G_s$ <b>2.58</b>	Project <b>CHASKA</b> NCS-IA-84-4-ED-GH			
PL <b>74</b>	$D_{10}$				
Remarks <b>Sample contained</b>		Area <b>HRD LAB NO: 84/34</b>			
<b>numerous shells.</b>		Boring No. <b>83-53 NU</b>	Sample No. <b>S-2</b>		
		Depth <b>26.8-28.8</b>	Date <b>10 JAN 1984</b>		
		<b>CONSOLIDATION TEST REPORT</b>			

DEFORMATION, INCHES



PROJECT: CHASKA

MRD LAB NO: 84-34

BORING NO: 83-53 MU

SAMPLE NO: S-2

DATE: 10 JAN 1984

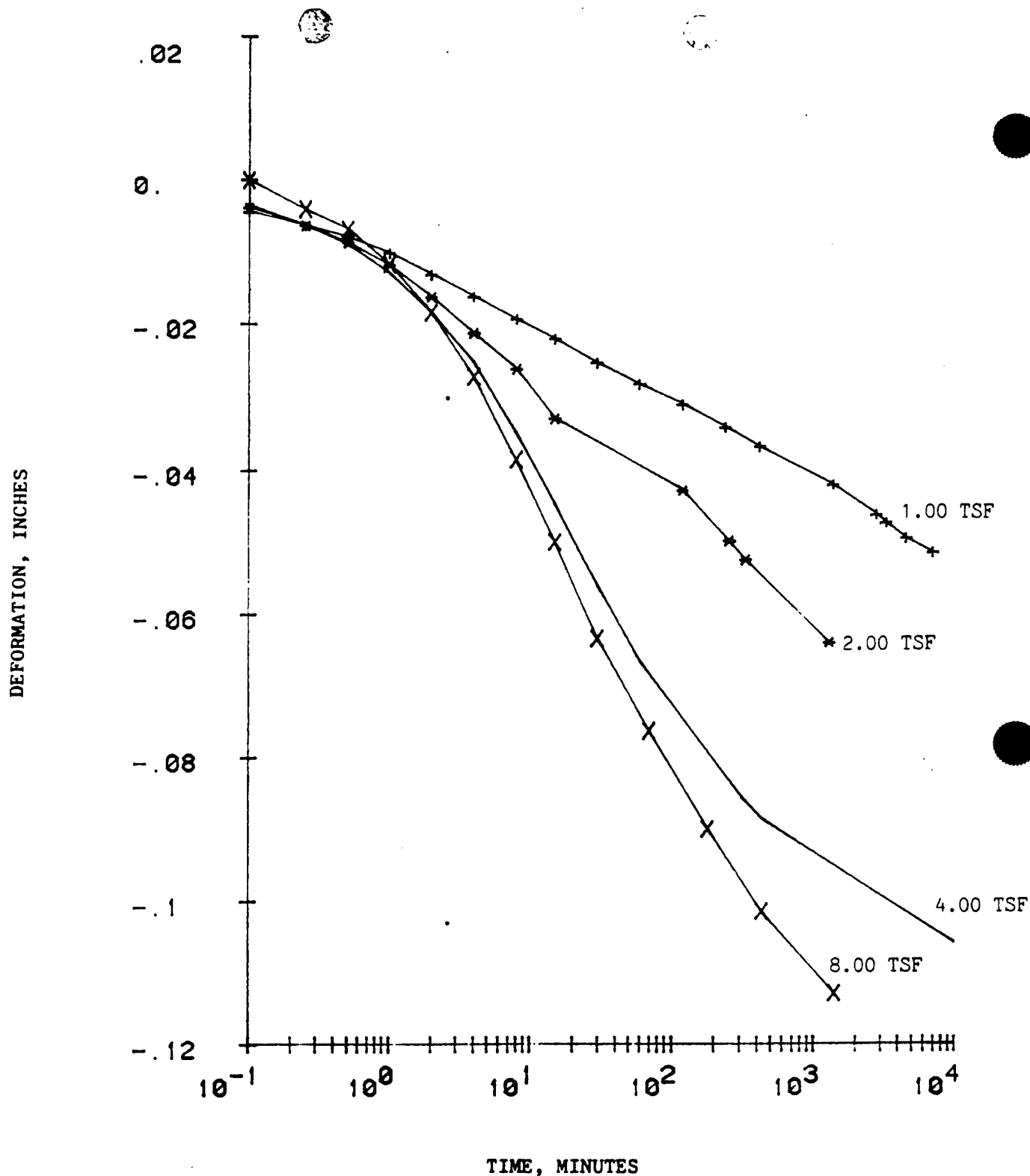
DEPTH/ELEV: 26.8-28.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 2

Figure C-91



PROJECT: CHASKA

MRD LAB NO: 84-34

BORING NO: 83-53 MU

SAMPLE NO: S-2

DATE 10 JAN 1984

DEPTH/ELEV: 26.8-26.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

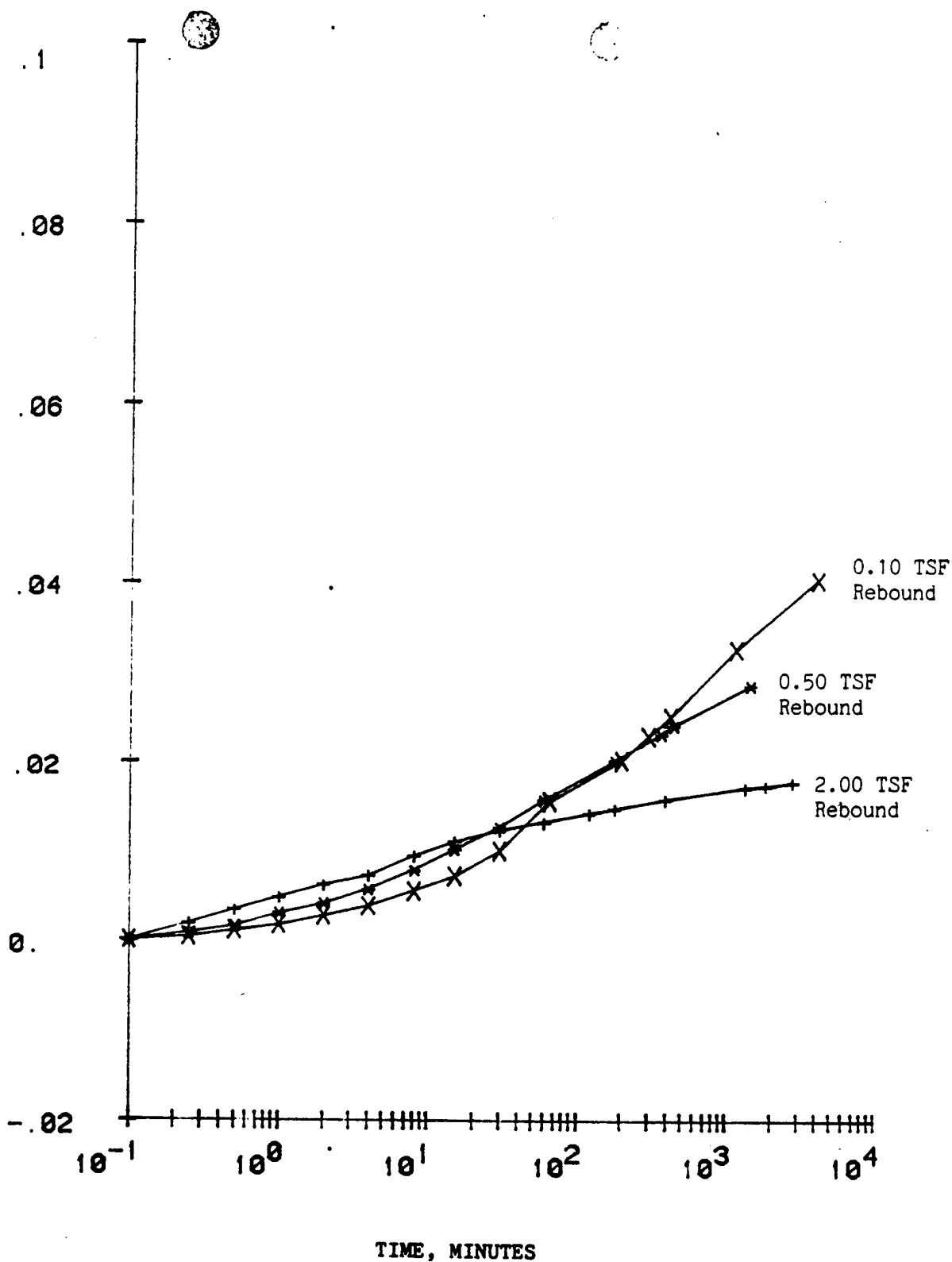
CONSOLIDATION TEST—TIME CURVES

FIGURE: 3

Figure C-92



DEFORMATION, INCHES



PROJECT: CHASKA

MRD LAB NO: 84-34

BORING NO: 63-53 MU

SAMPLE NO: S-2

DATE: 10 JAN 1984

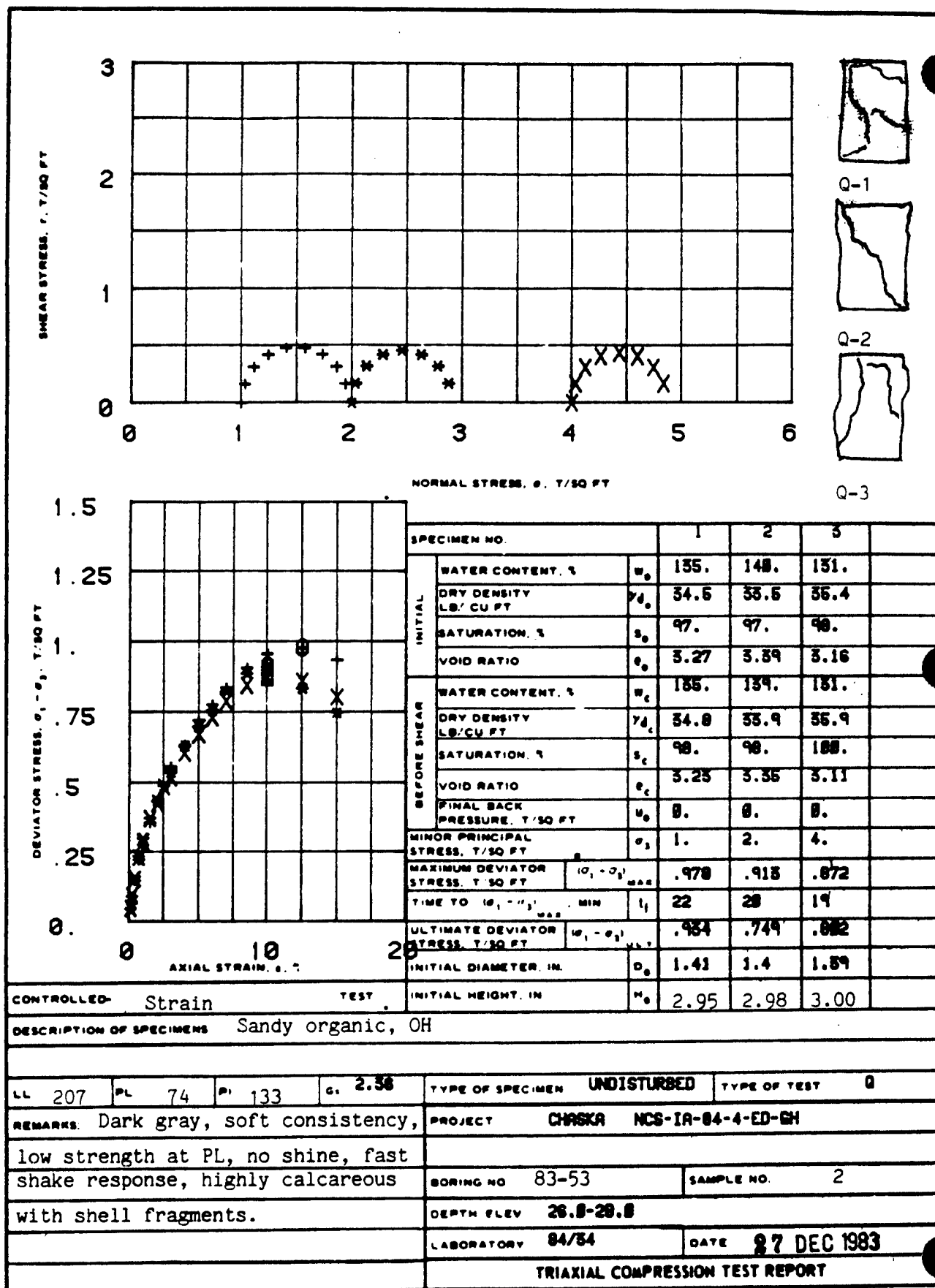
DEPTH/ELEV: 26.8-28.8

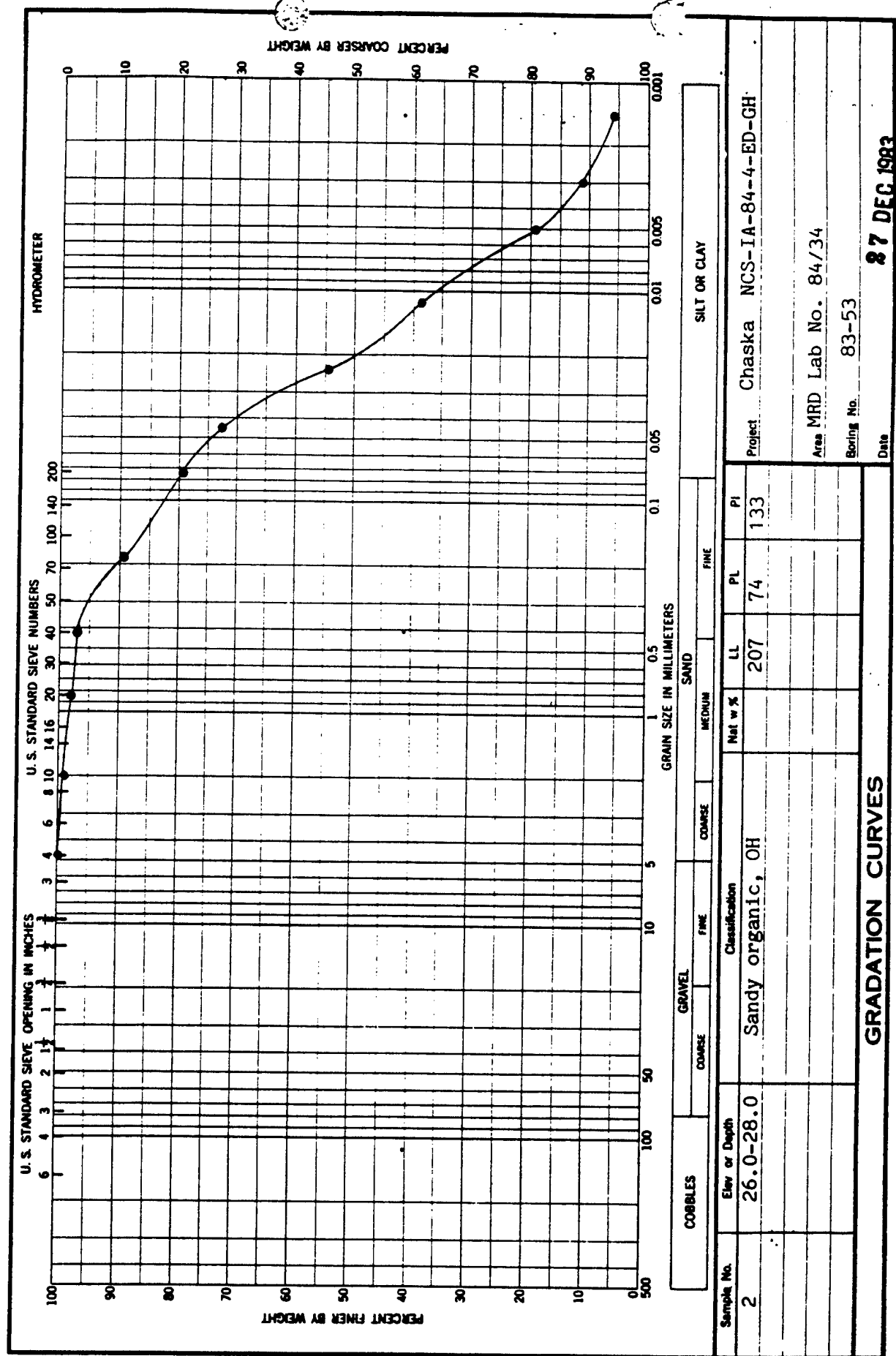
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 4

Figure C-93

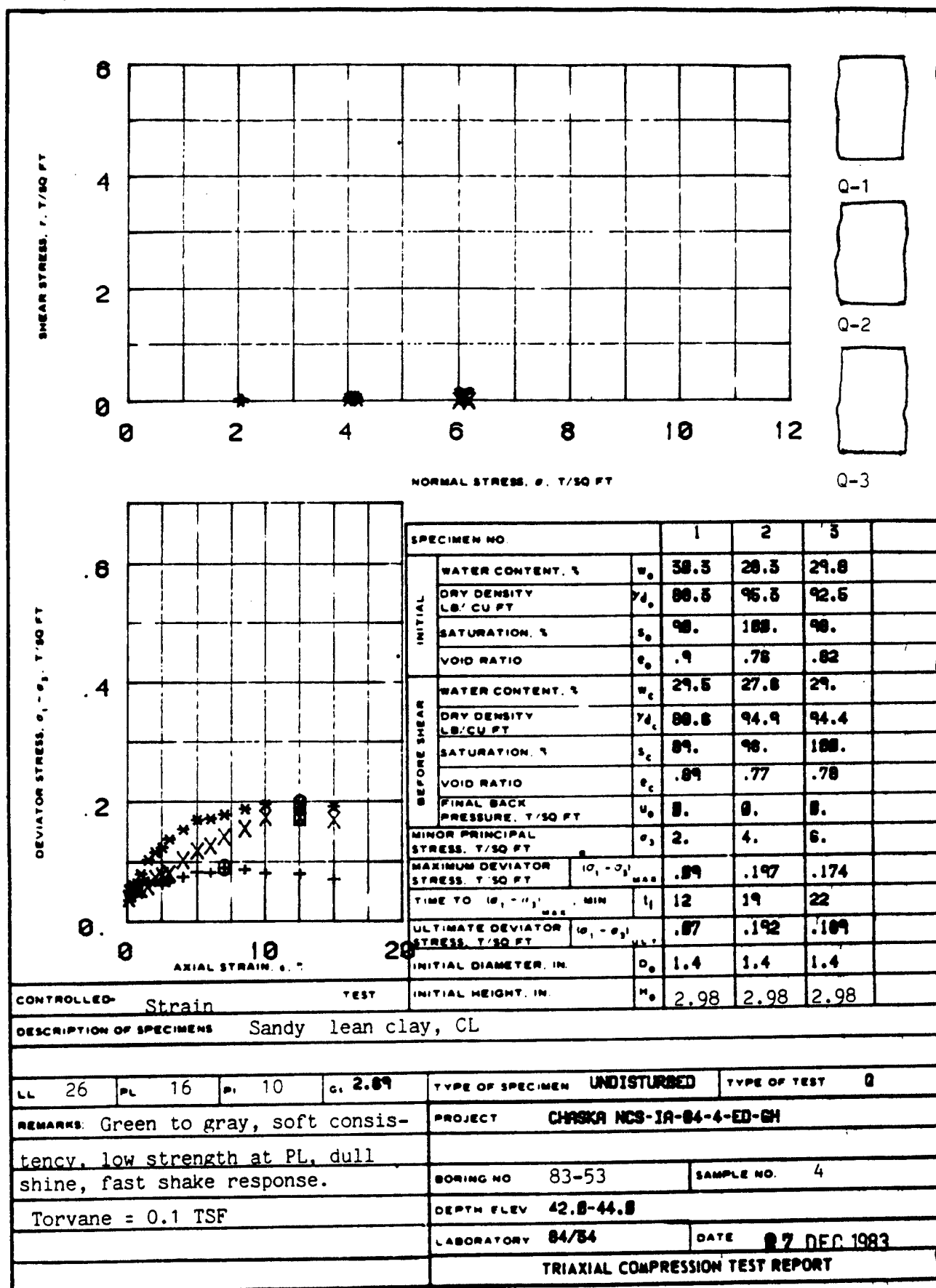


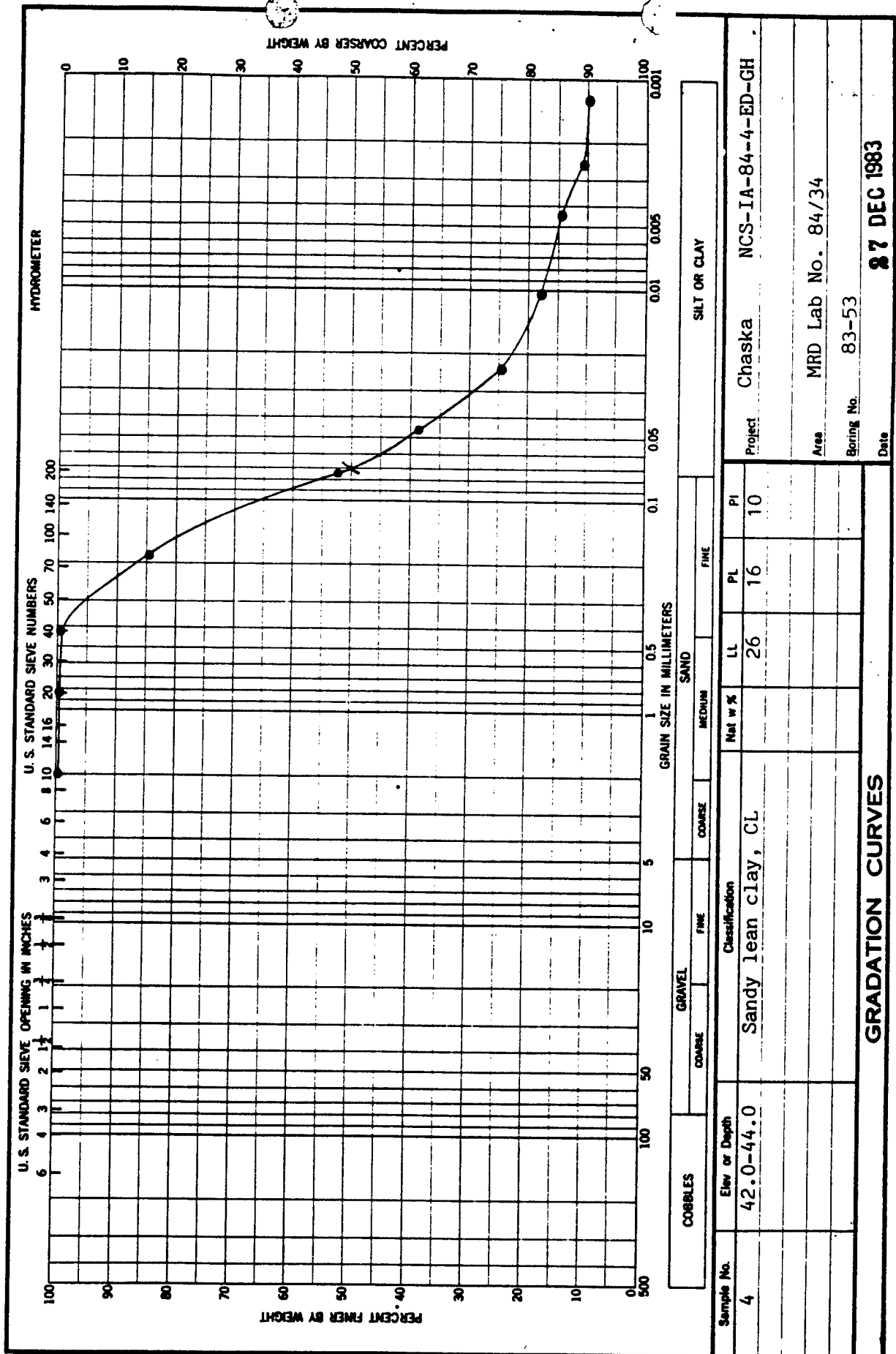


ENG FORM 1 MAY 83 2087

Figure C-95

Figure 15

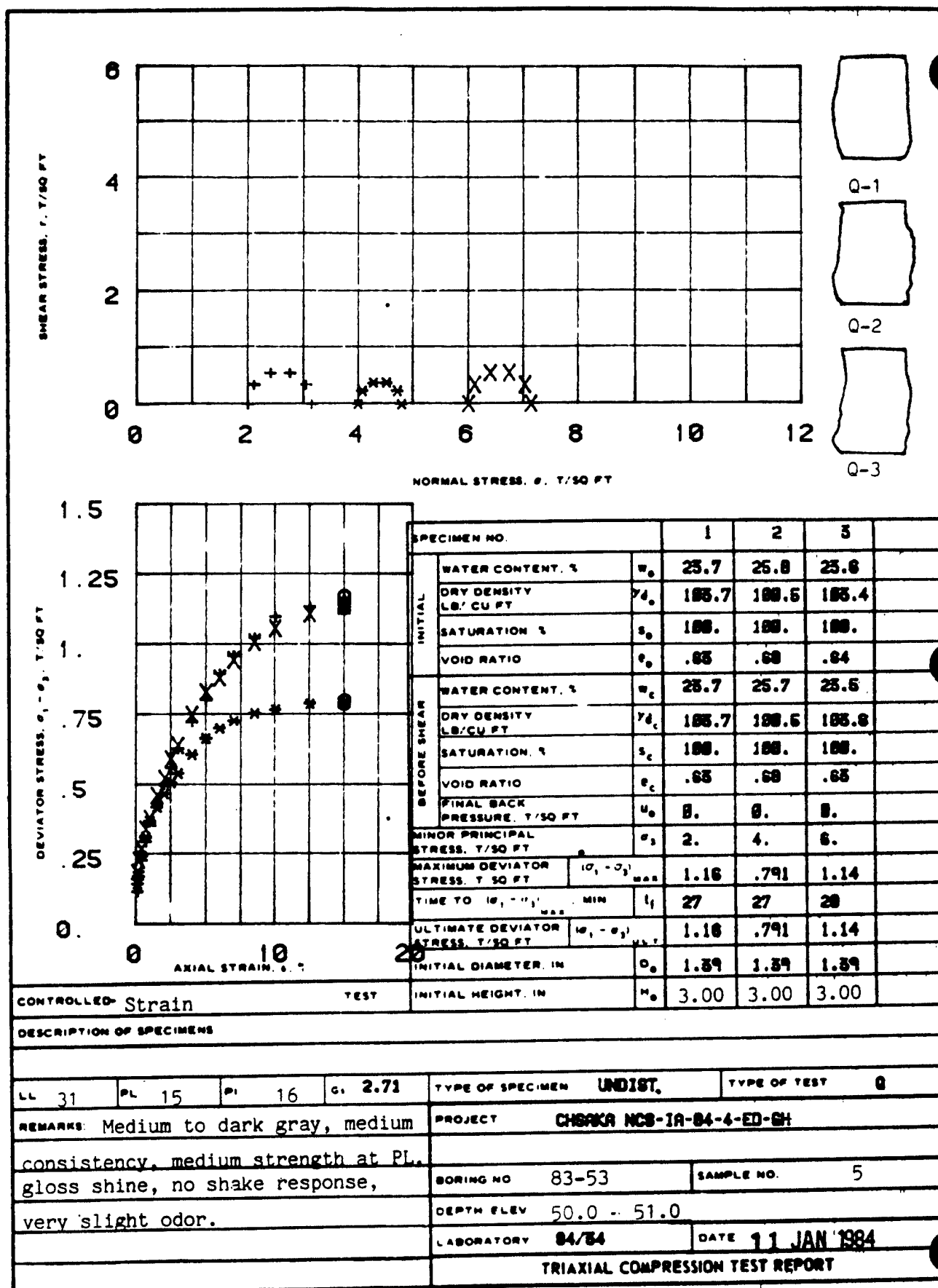




ENG FORM  
1 MAY 65 2087

Figure C-97

Figure 17



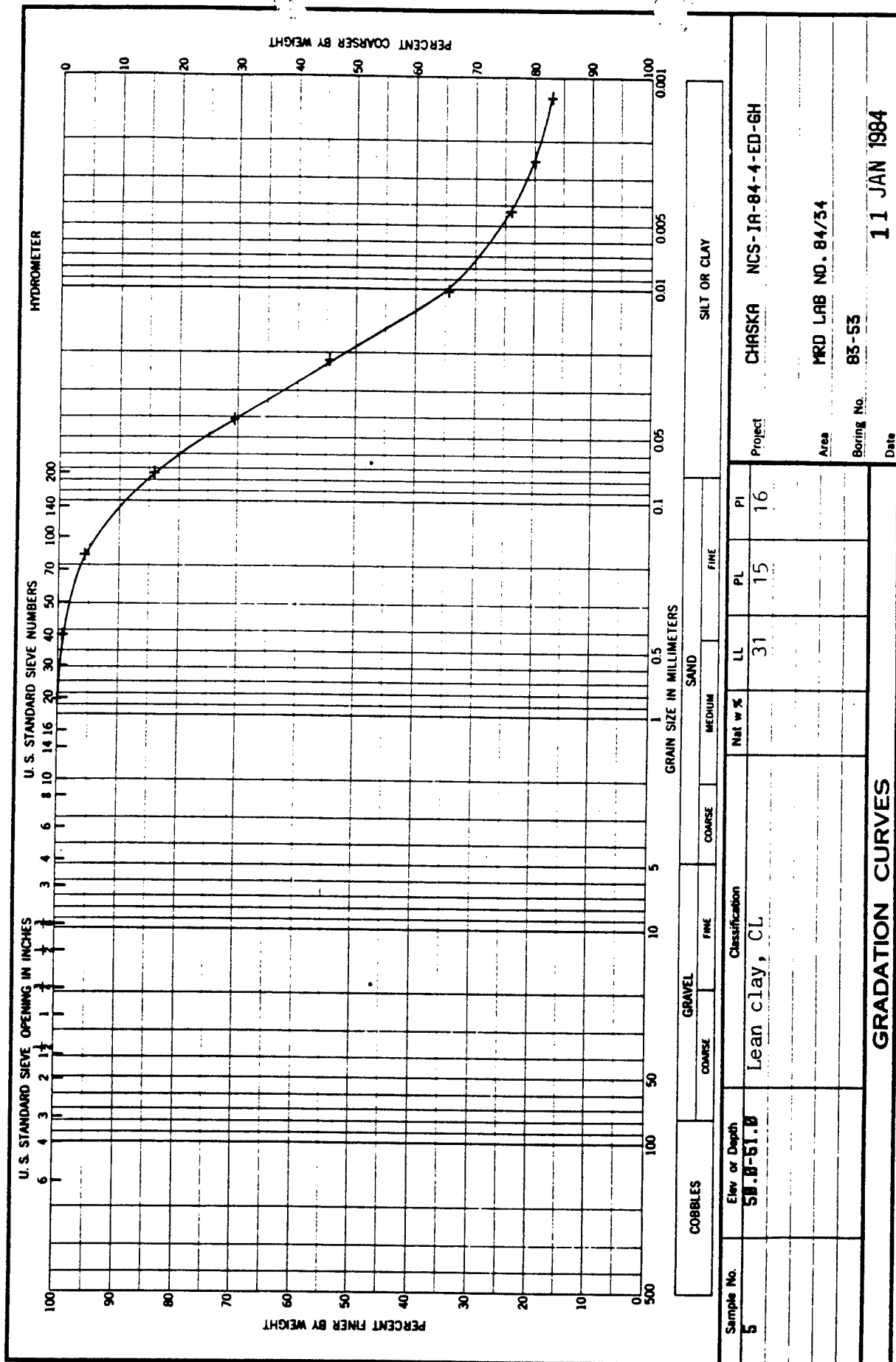
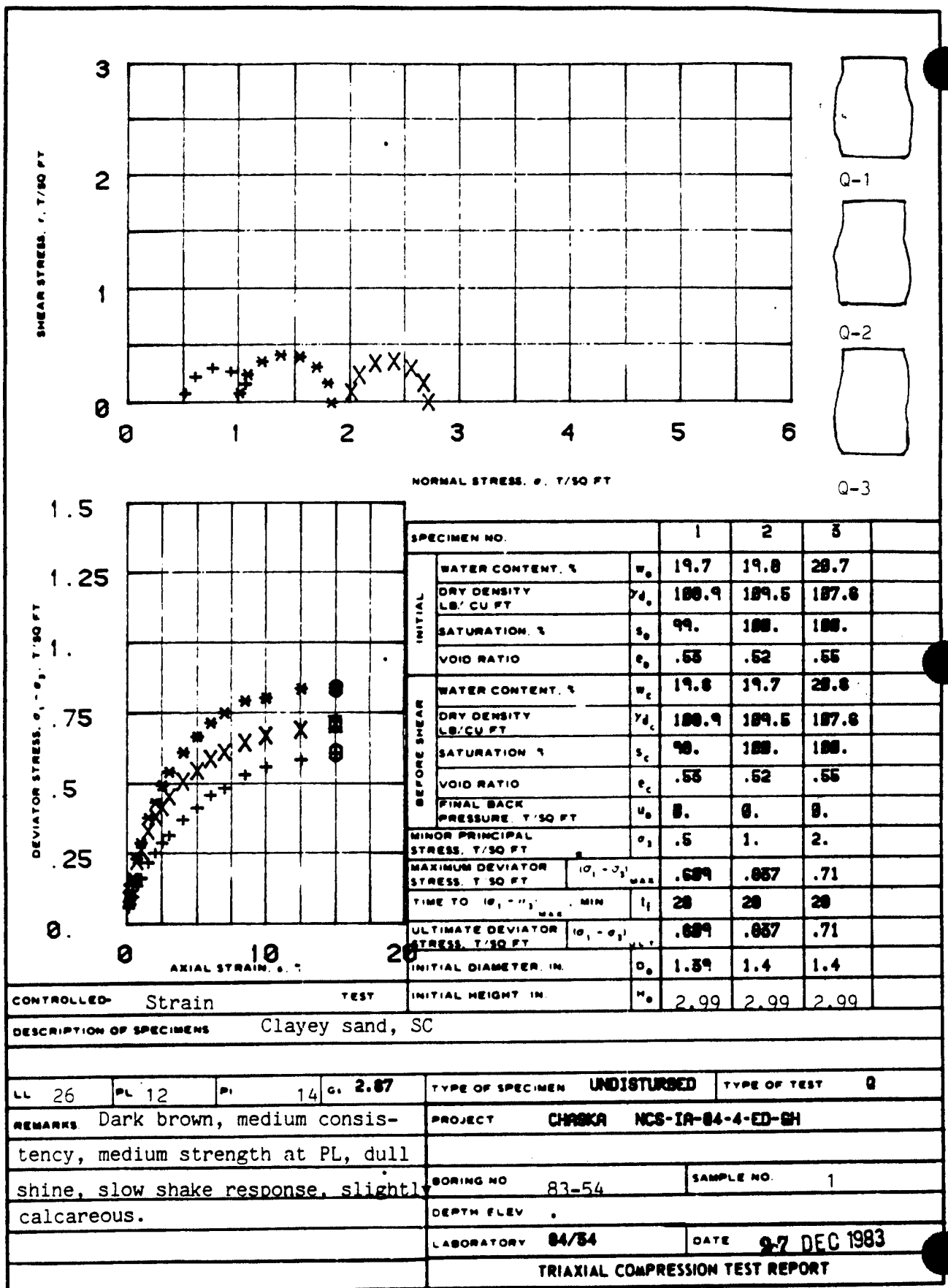
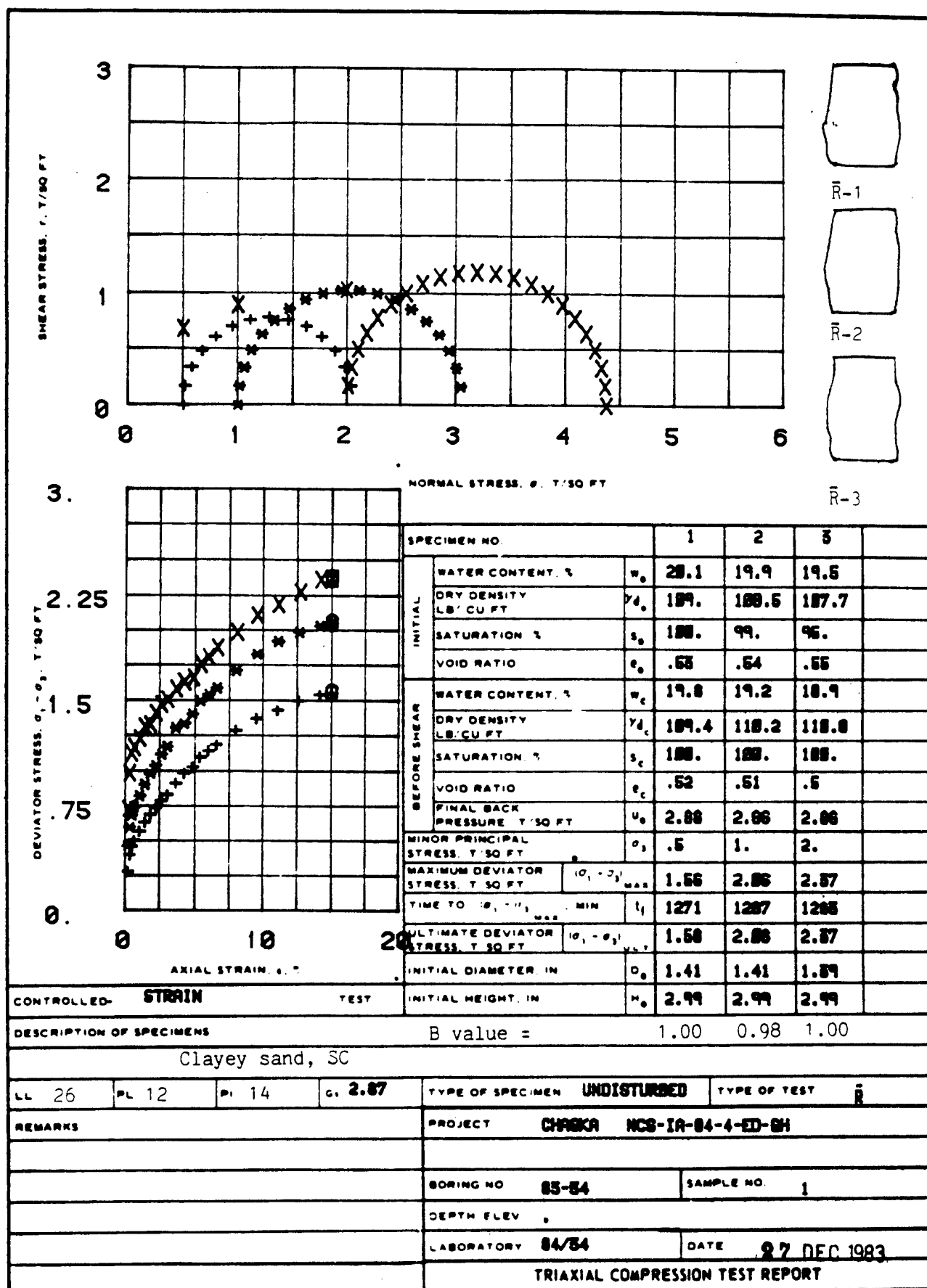


Figure C-99







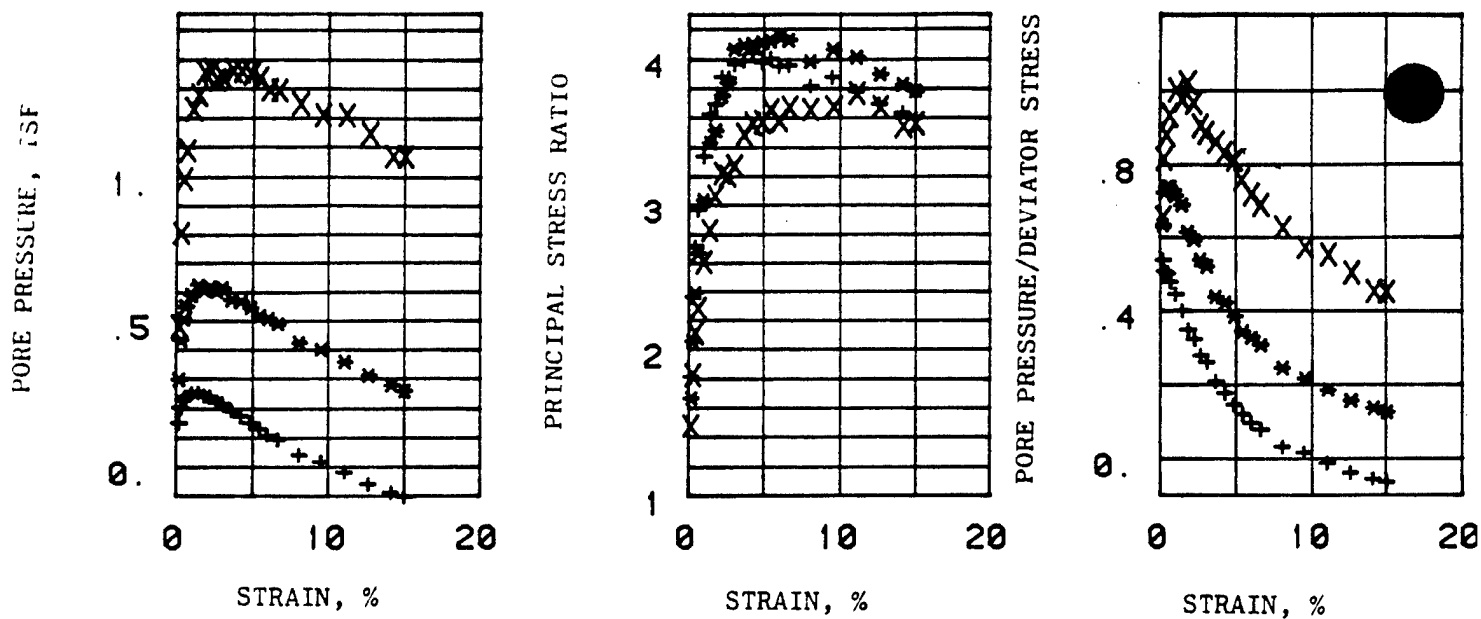
ENG FORM NO 2089  
REV JUNE 1970

PREVIOUS EDITION IS OBSOLETE

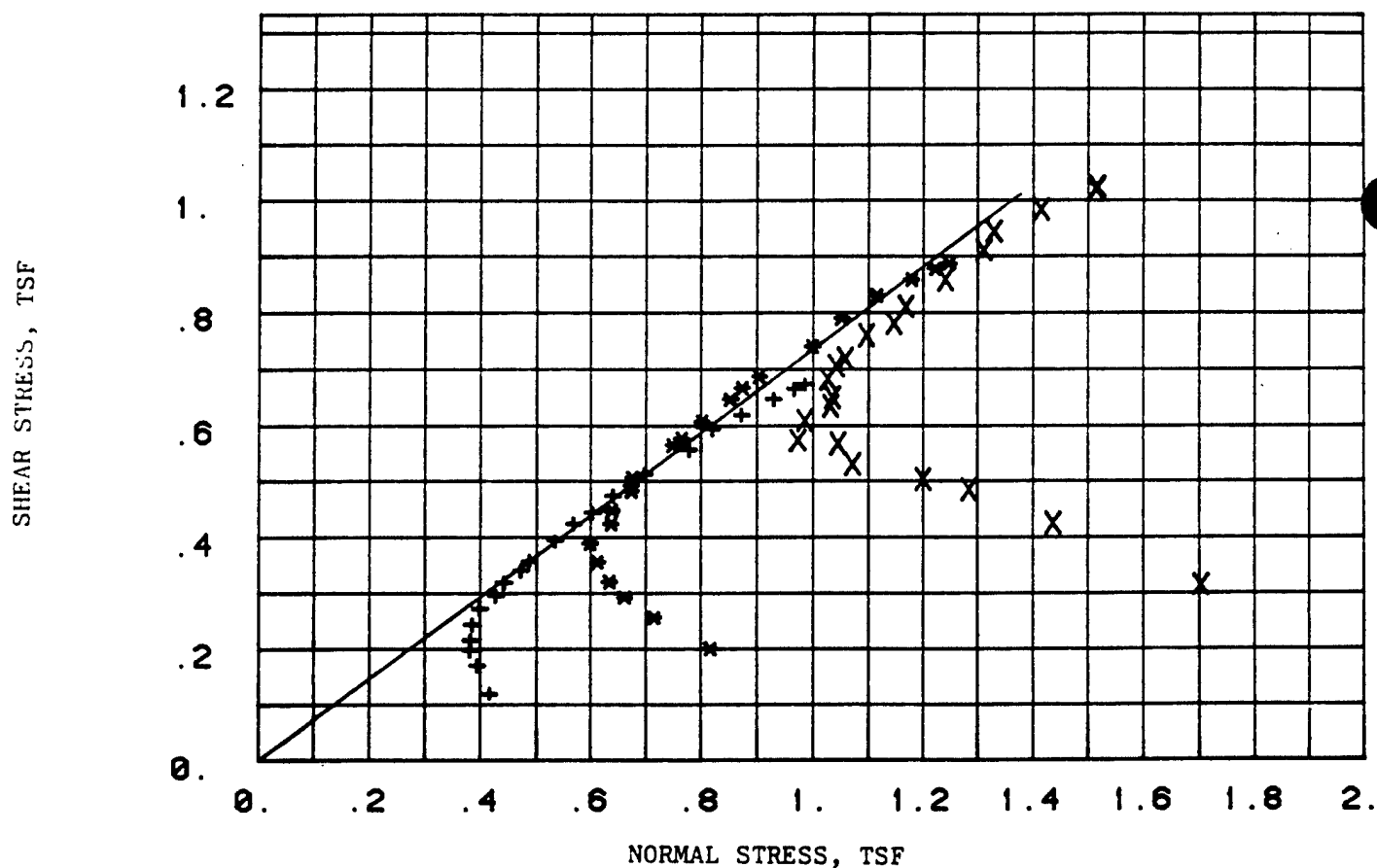
TRANSLUCENT

(EM 1110-2-1906)

Figure 19



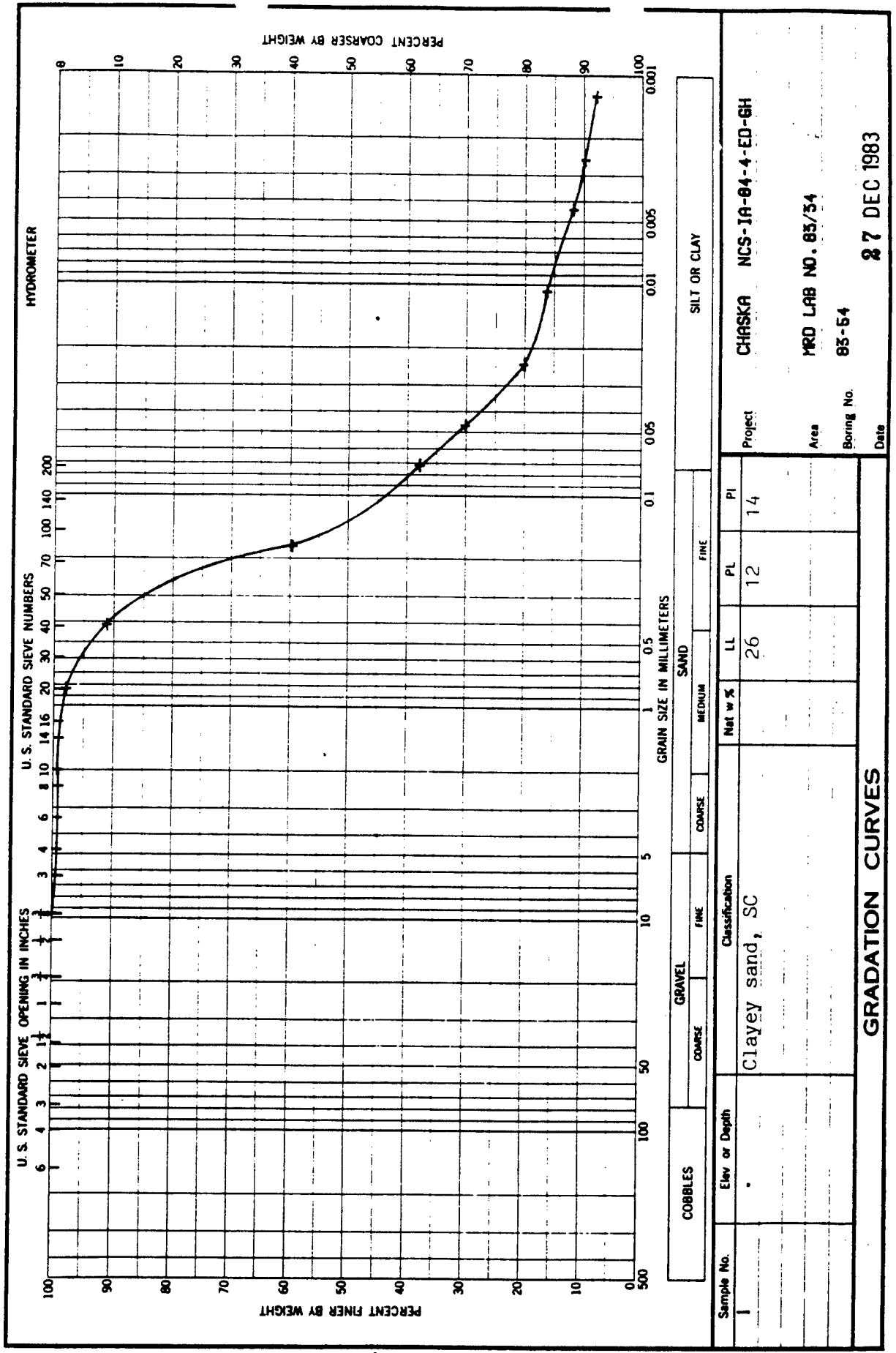
EFFECTIVE STRESS VECTOR CURVES ON  $60^\circ$  DEGREE PLANE



REMARKS: COMPUTER PRINT-OUT  
 SYMBOLS SAME AS FORM 2089  
 TRIAXIAL TEST: PORE PRESSURE  
 MONITORED DURING SHEAR

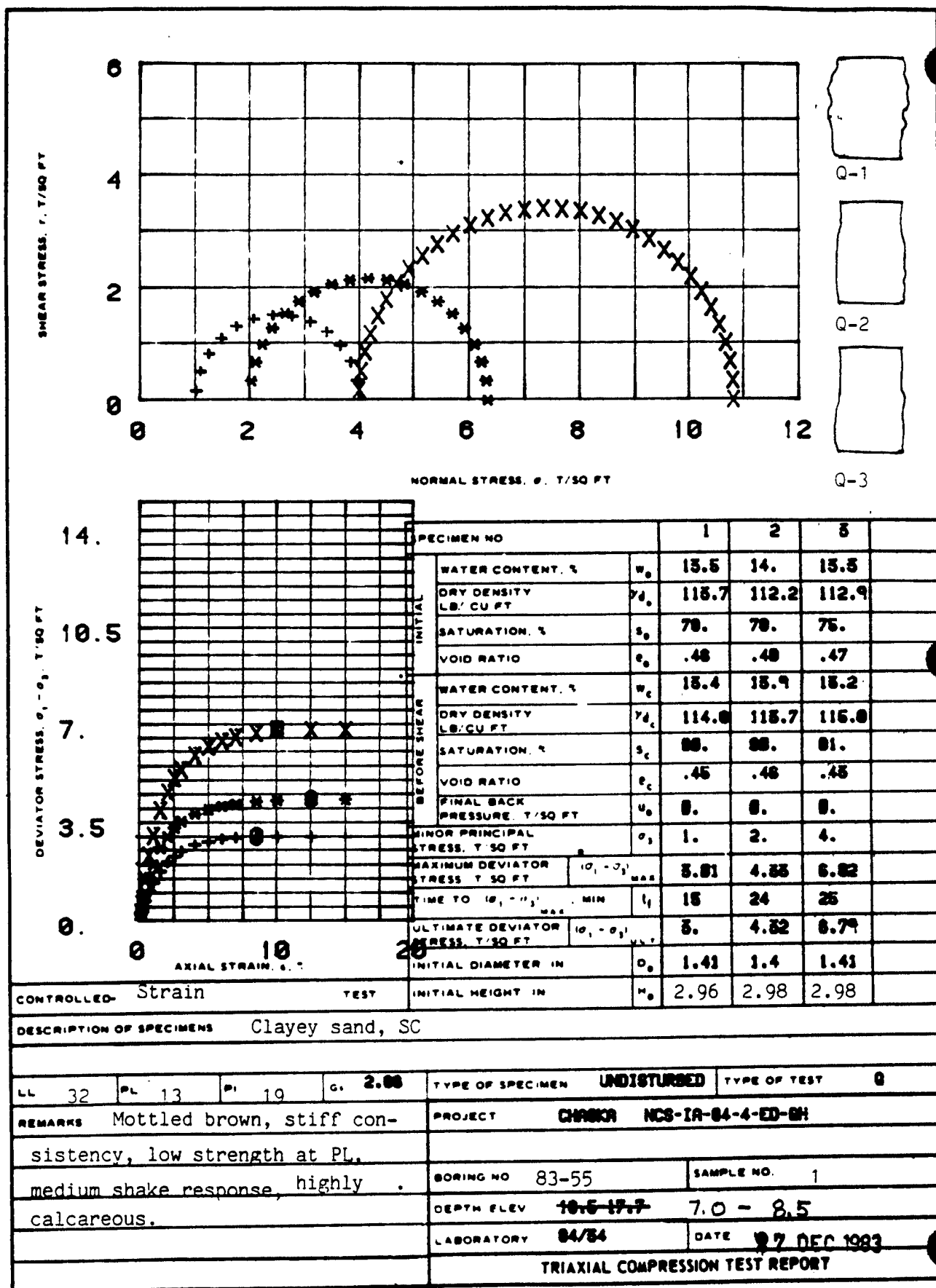
PROJECT: CHASKA NCS-1A-84-4-ED-6H  
 BORING NO: 85-54 SAMPLE NO: 1  
 DEPTH/ELEV: MRD LAB NO: 84/54 DATE: 27 DEC 1983

TRIAXIAL COMPRESSION TEST REPORT



<b>GRADATION CURVES</b>						
Sample No. 1	Elev or Depth .	Classification Clayey sand, SC	Net w % 26	LL 12	PL 14	PI 14
		Project CHASKA NCS-IA-84-4-ED-6H	Area MRD LAB NO. 83/34		Boring No. 83-54	
		Date 27 DEC 1983				

Figure C-103



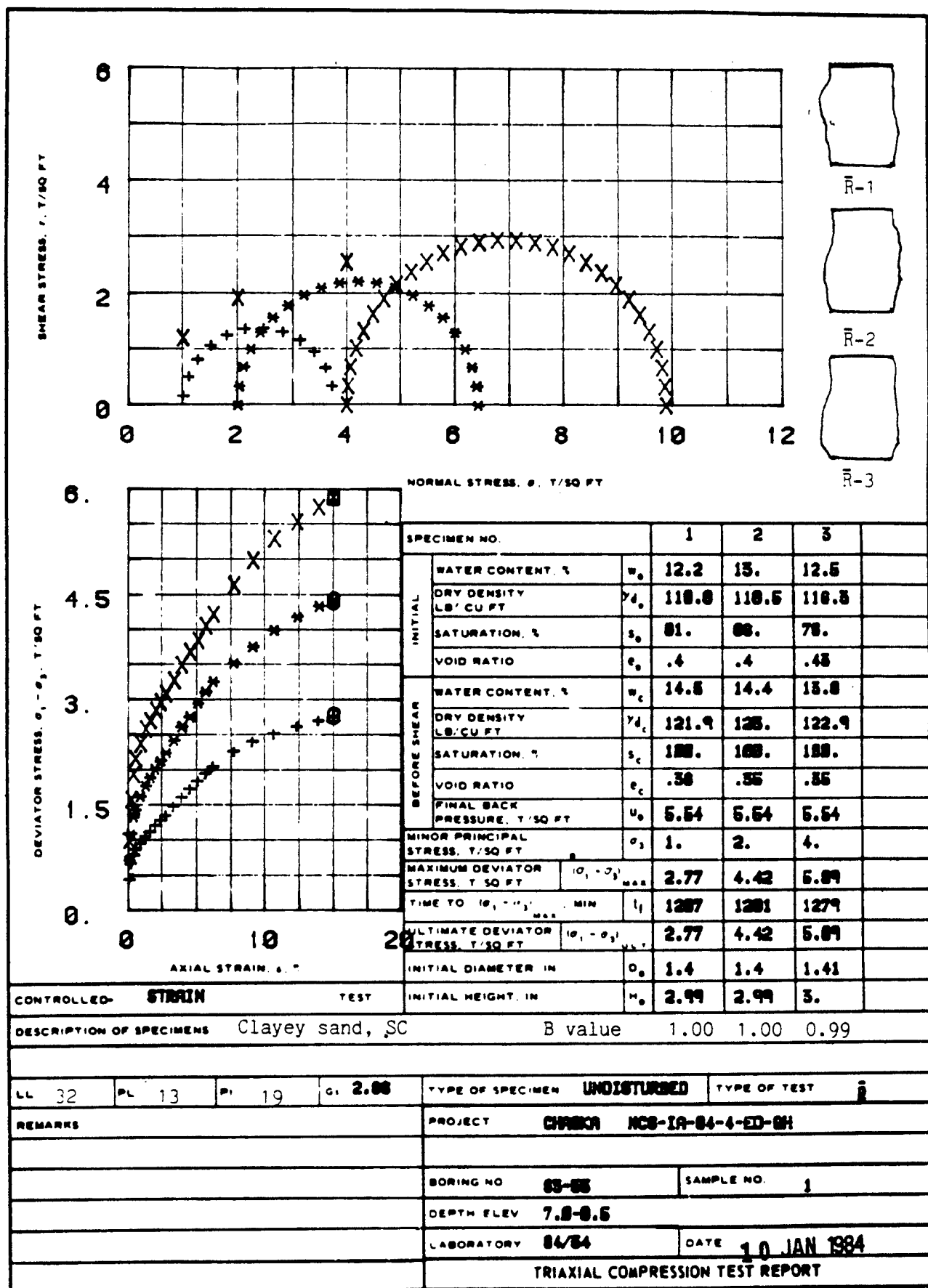
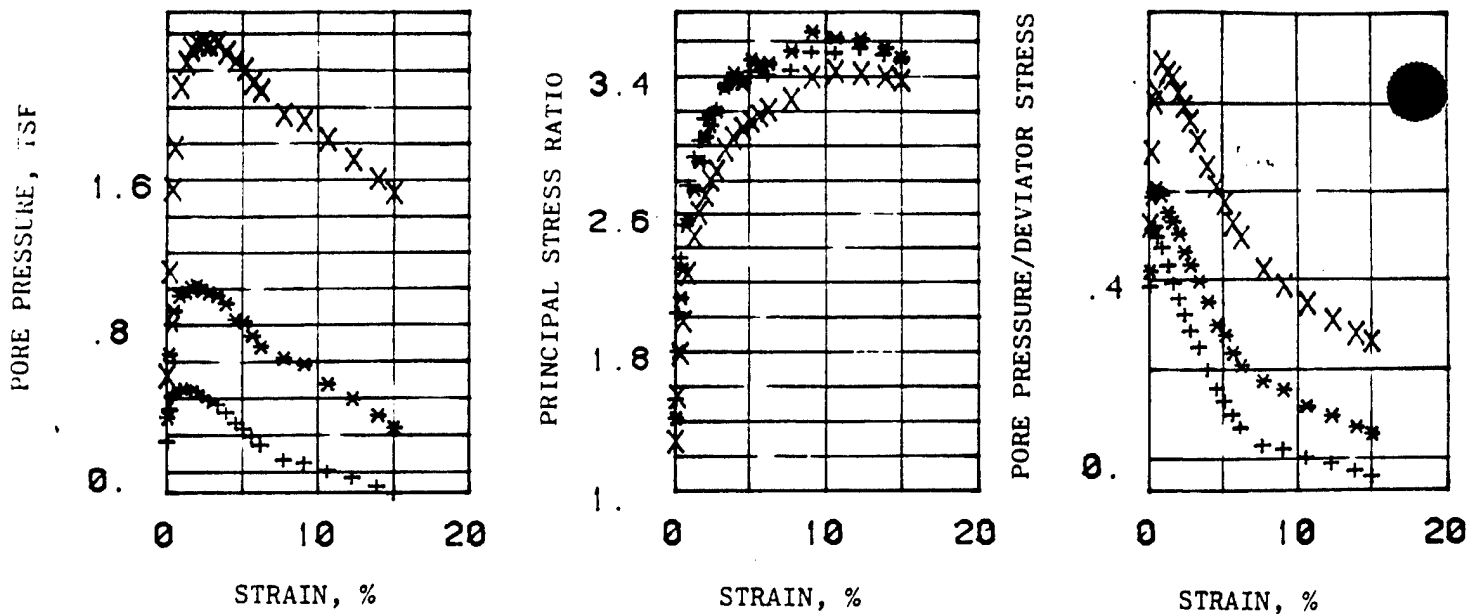
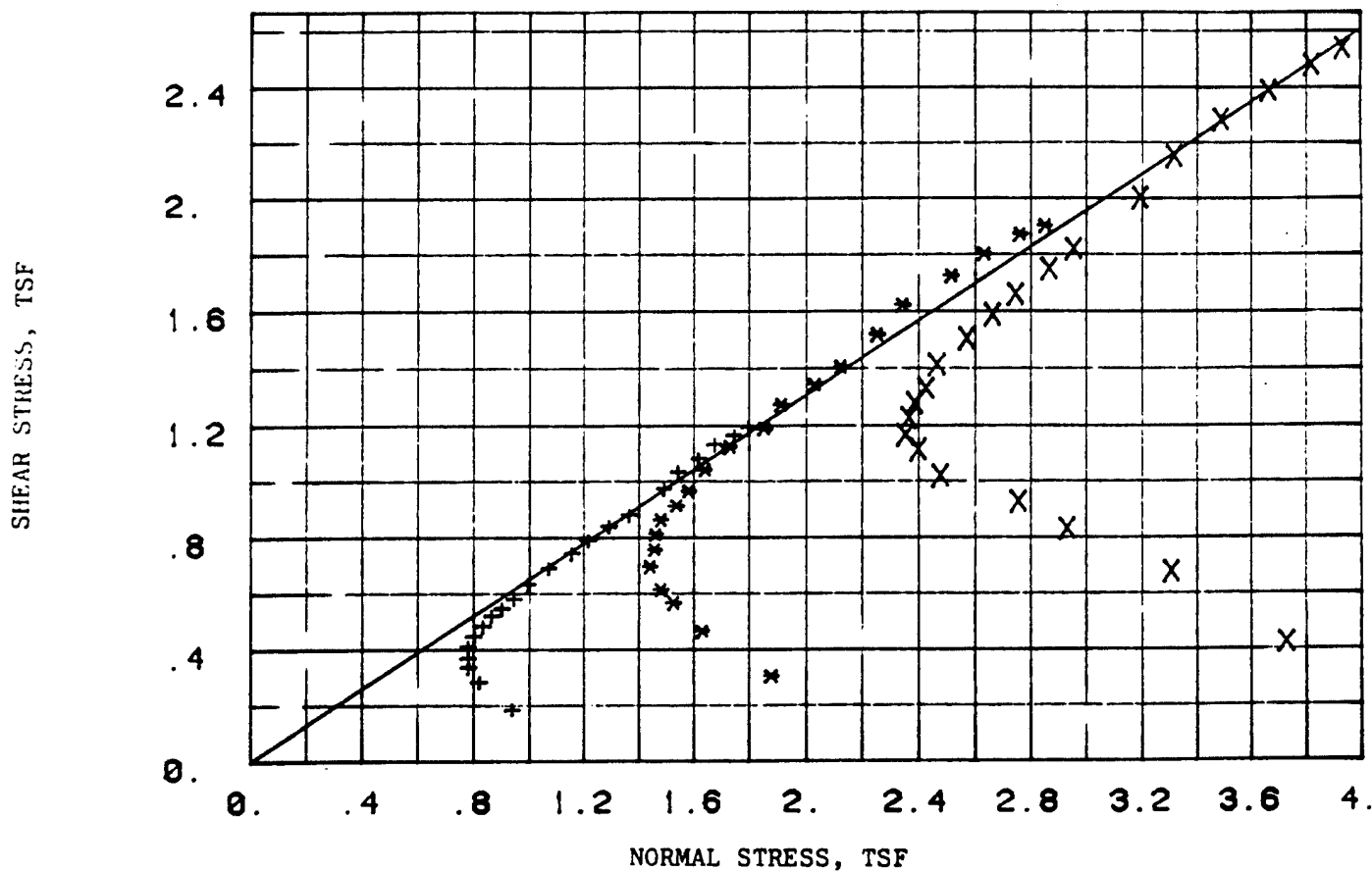


Figure 5



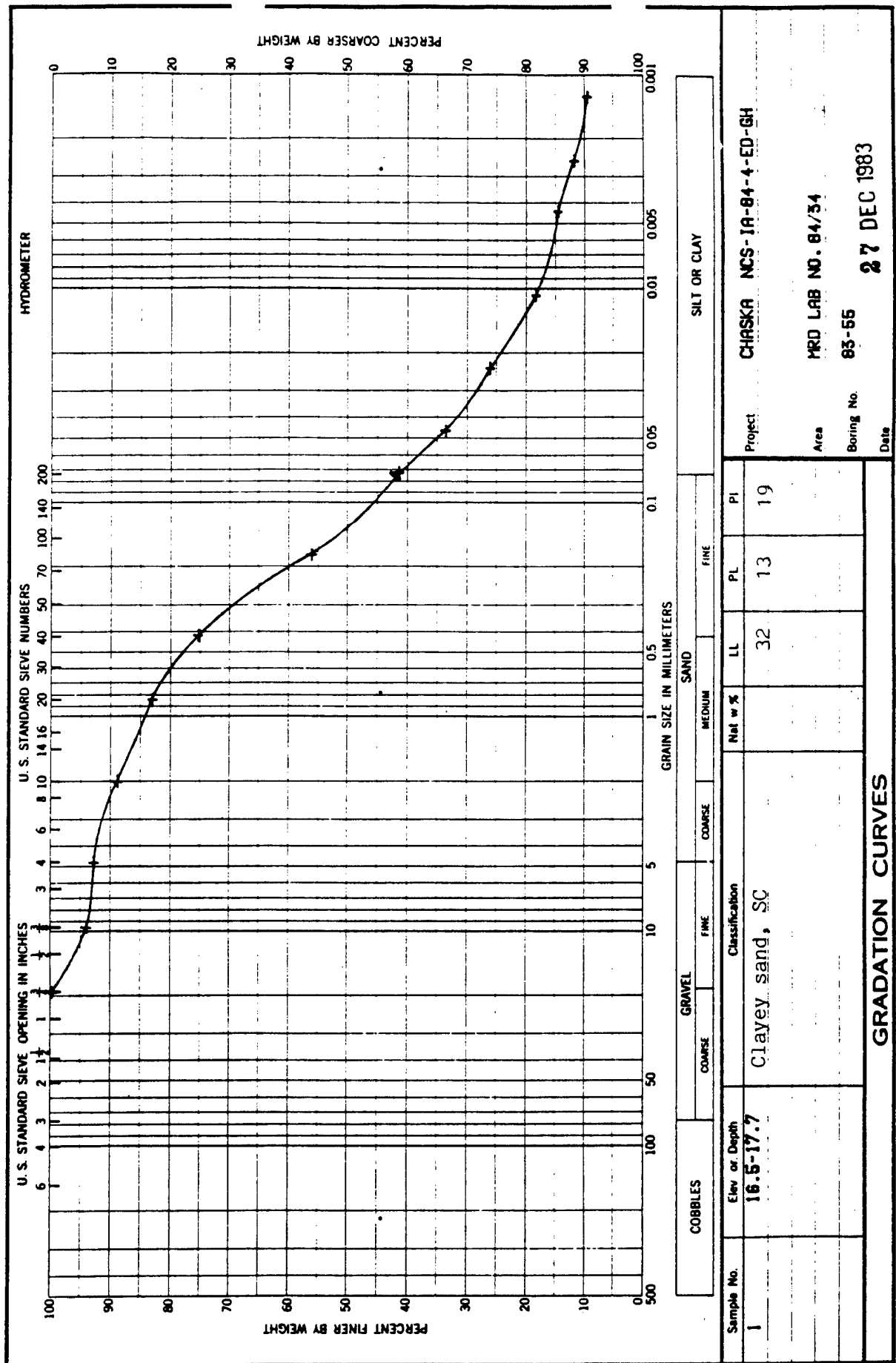
EFFECTIVE STRESS VECTOR CURVES ON  $\sigma_1$  DEGREE PLANE

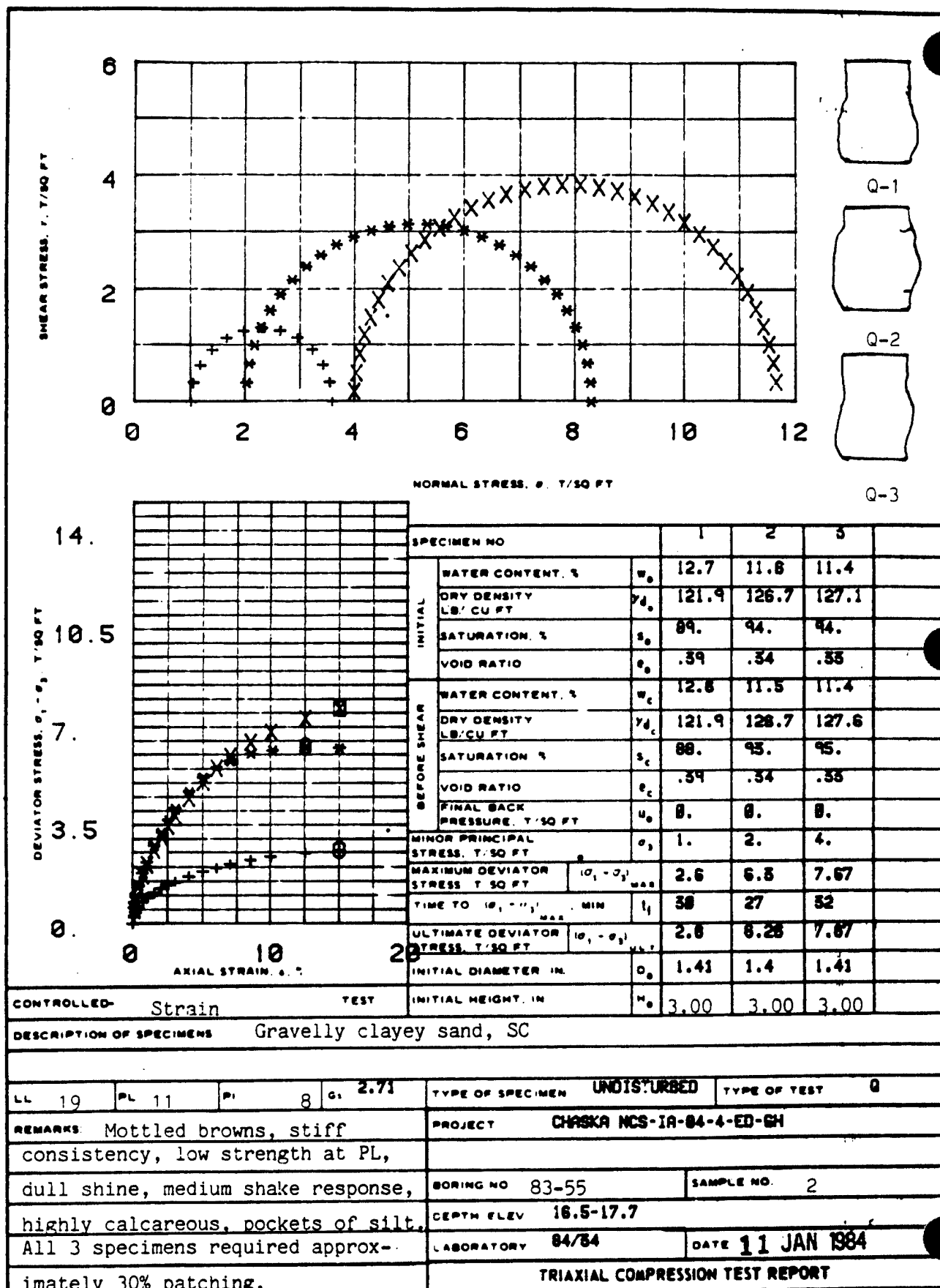


REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
R TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

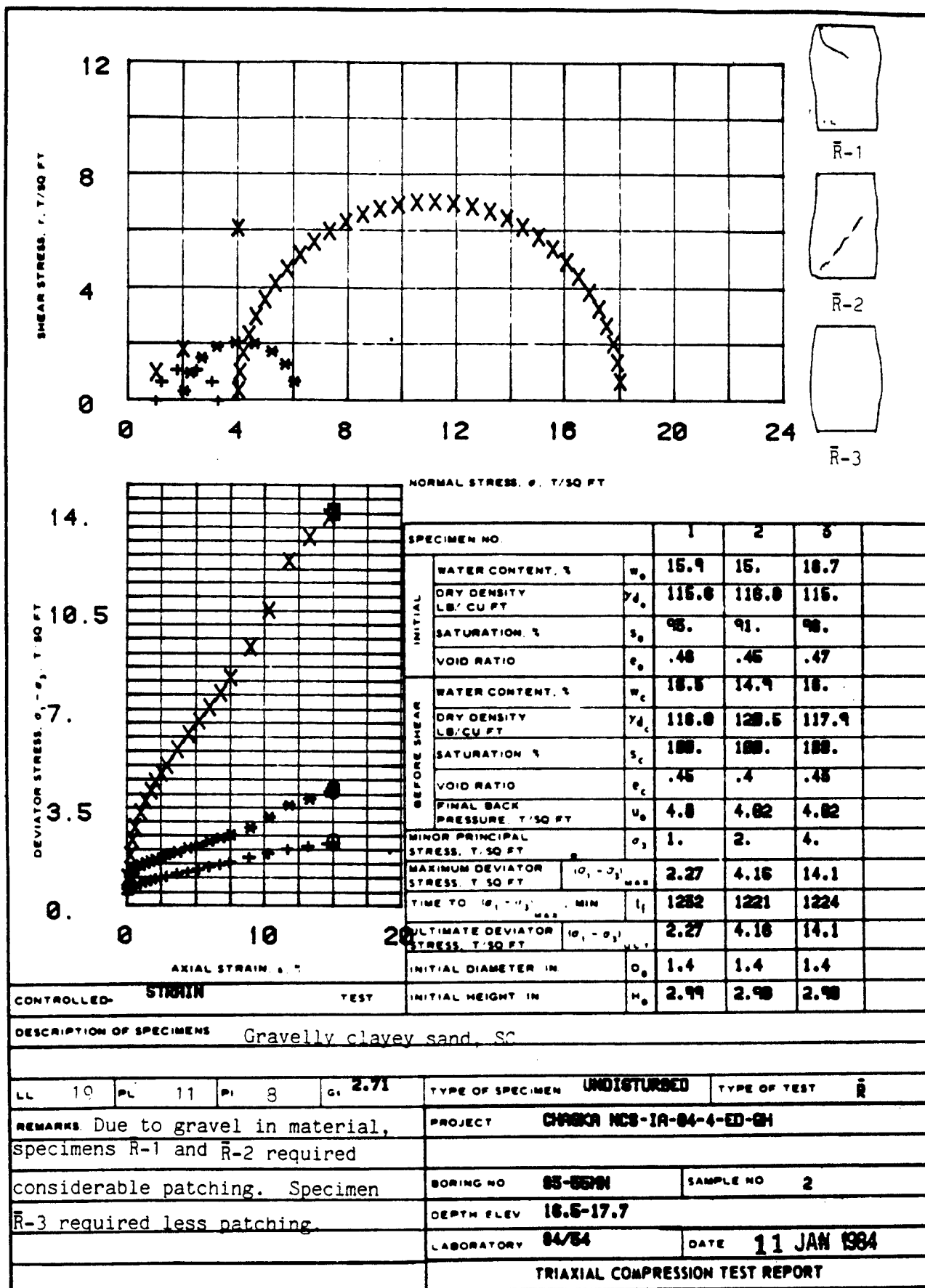
PROJECT: CHSKA NCS-1A-84-4-ED-6H  
BORING NO: 63-55 SAMPLE NO: 1  
DEPTH/ELEV: 7.8-8.5  
MRD LAB NO: 84/54 DATE: 10 JAN 1984

TRIAXIAL COMPRESSION TEST REPORT

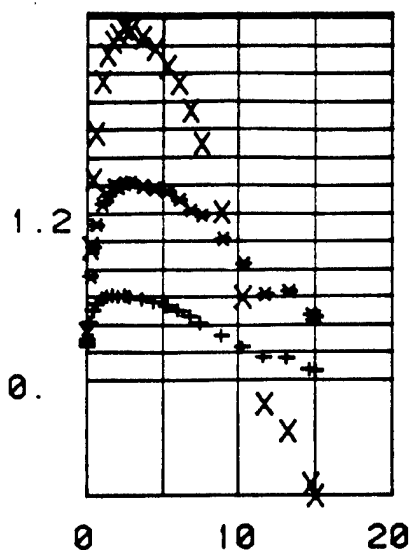




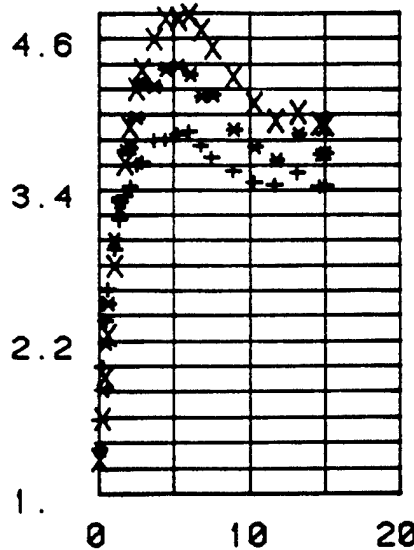




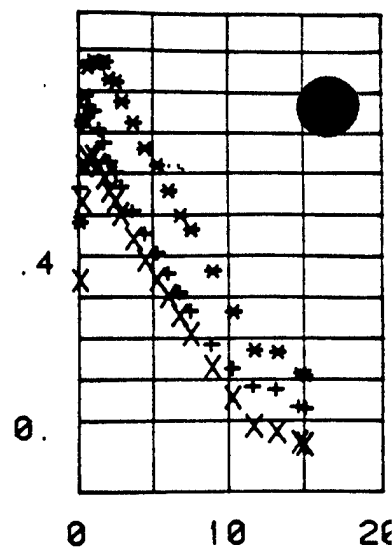
PORE PRESSURE, TSF



PRINCIPAL STRESS RATIO



PORE PRESSURE/DEVIATOR STRESS



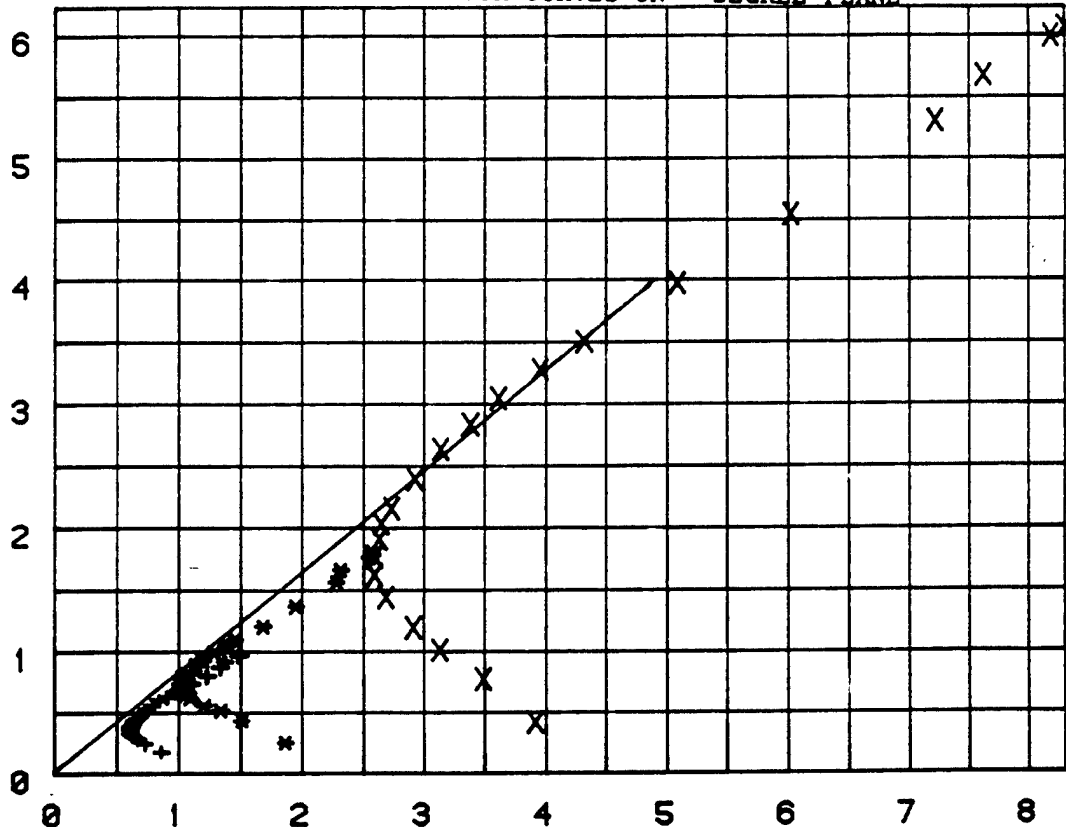
STRAIN, %

STRAIN, %

STRAIN, %

EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE

SHEAR STRESS, TSF



NORMAL STRESS, TSF

REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
R TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-84-4-ED-GH  
BORING NO: 83-55M SAMPLE NO: 2  
DEPTH/ELEV: 16.5-17.7  
MRD LAB NO: 84/34 DATE: 11 JAN 1984

TRIAXIAL COMPRESSION TEST REPORT

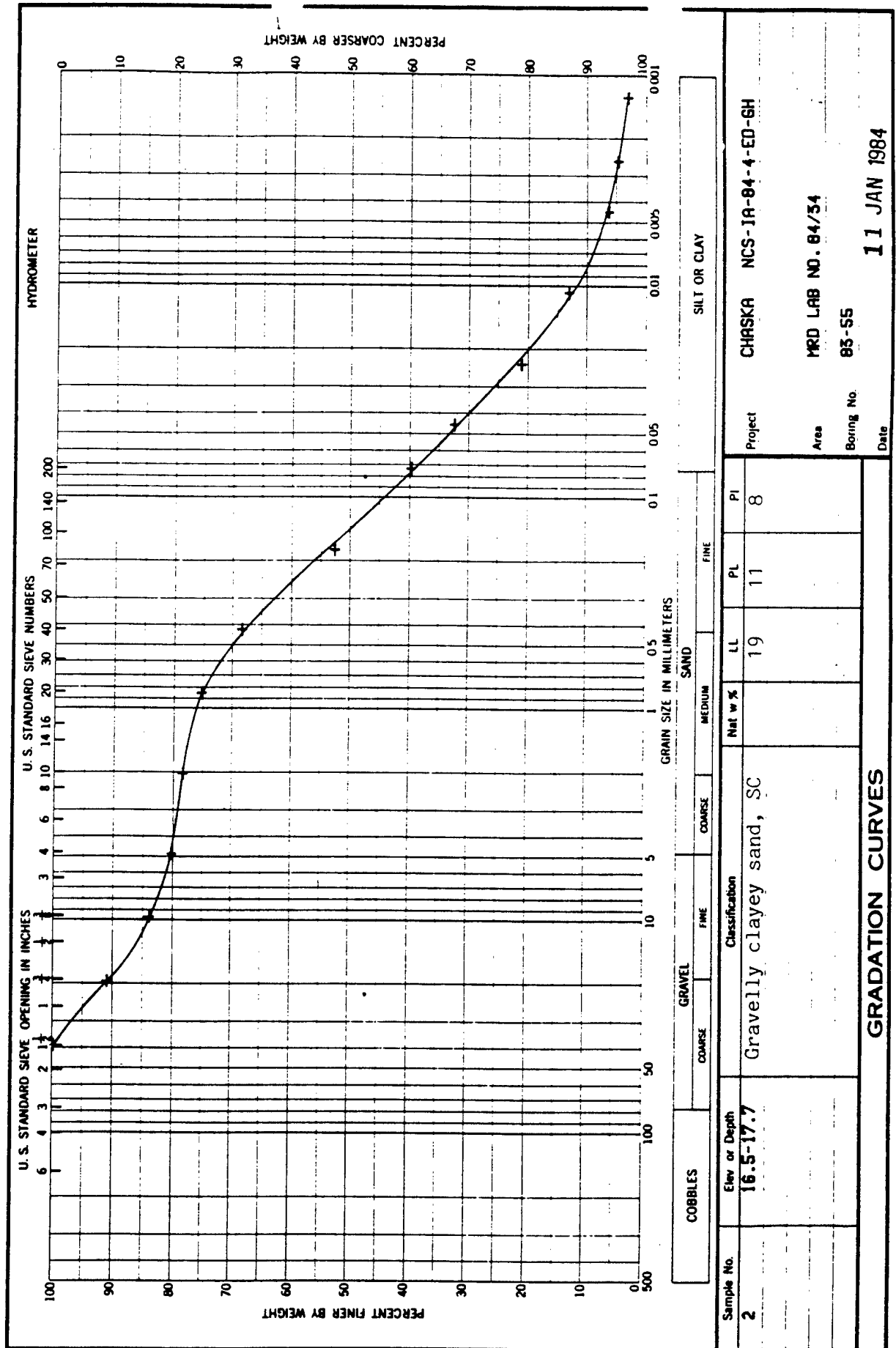
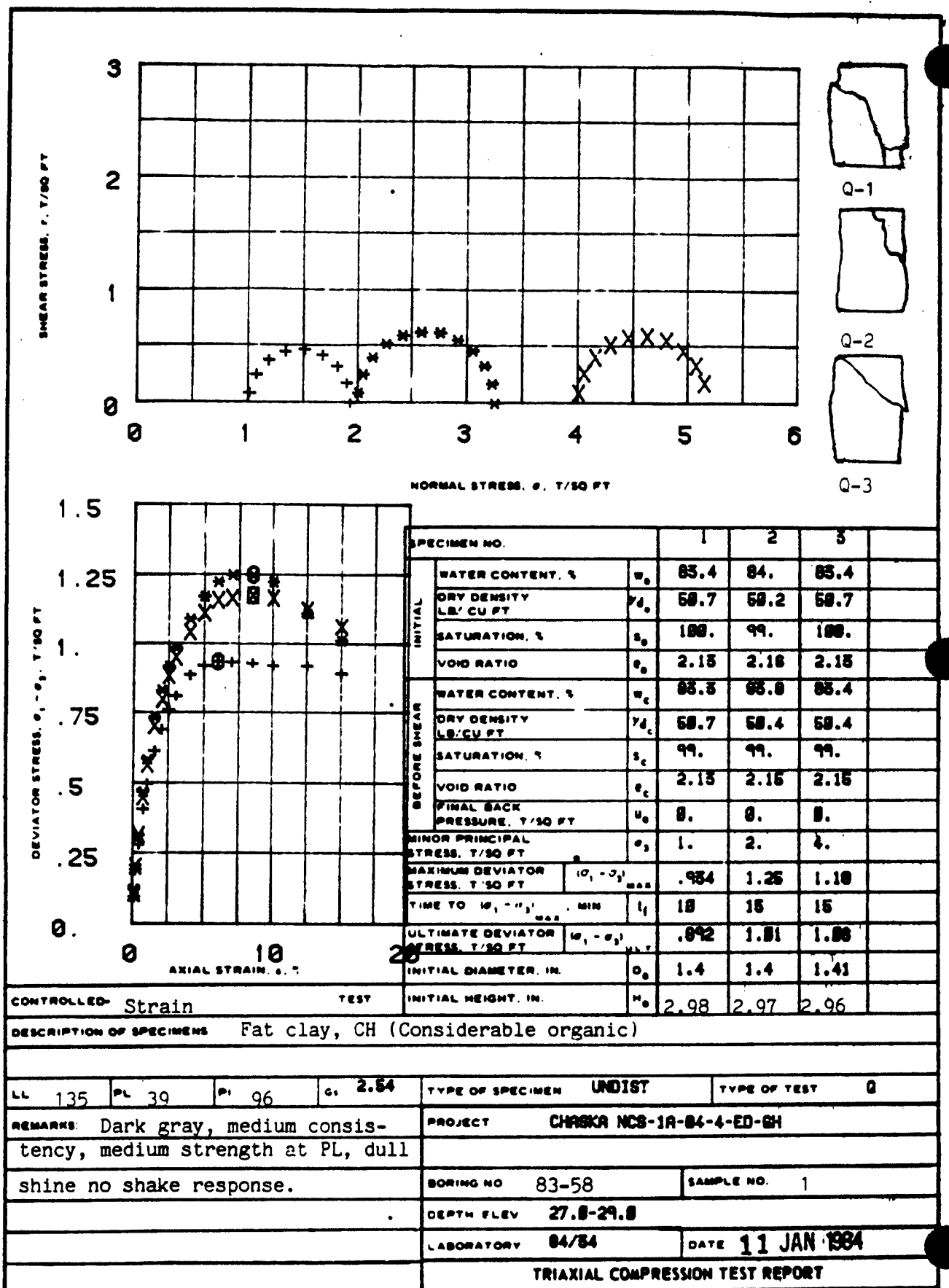
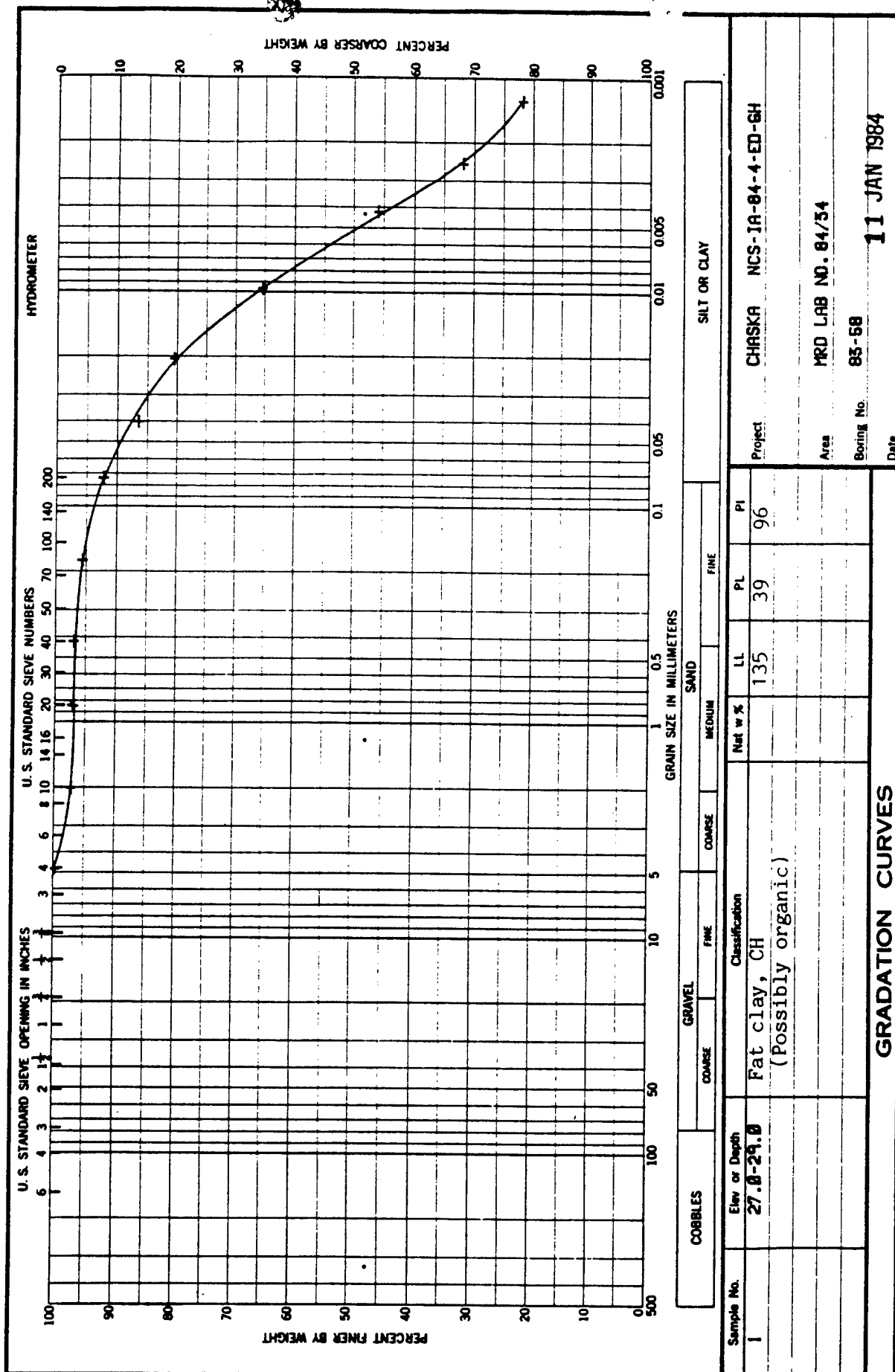
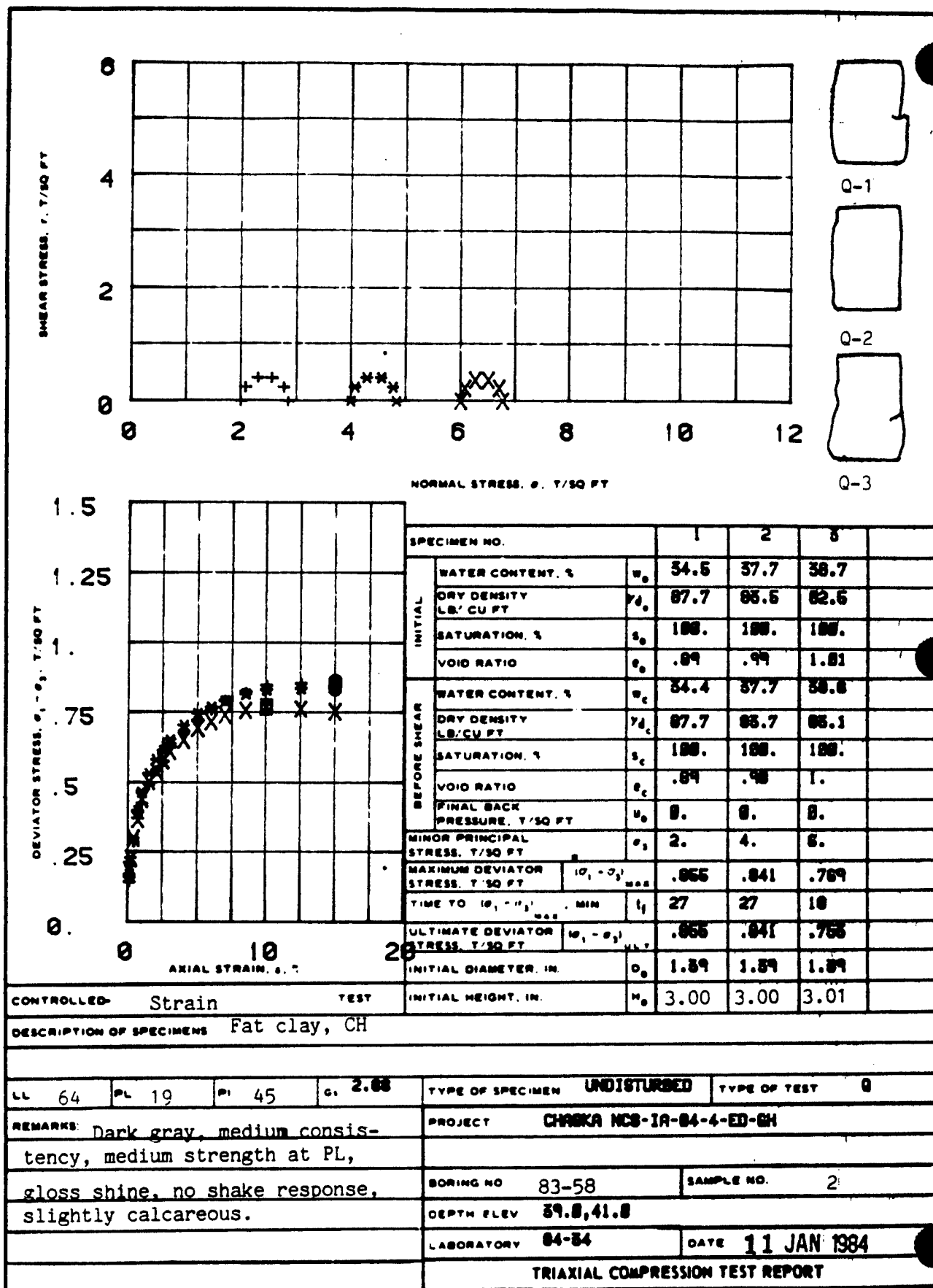


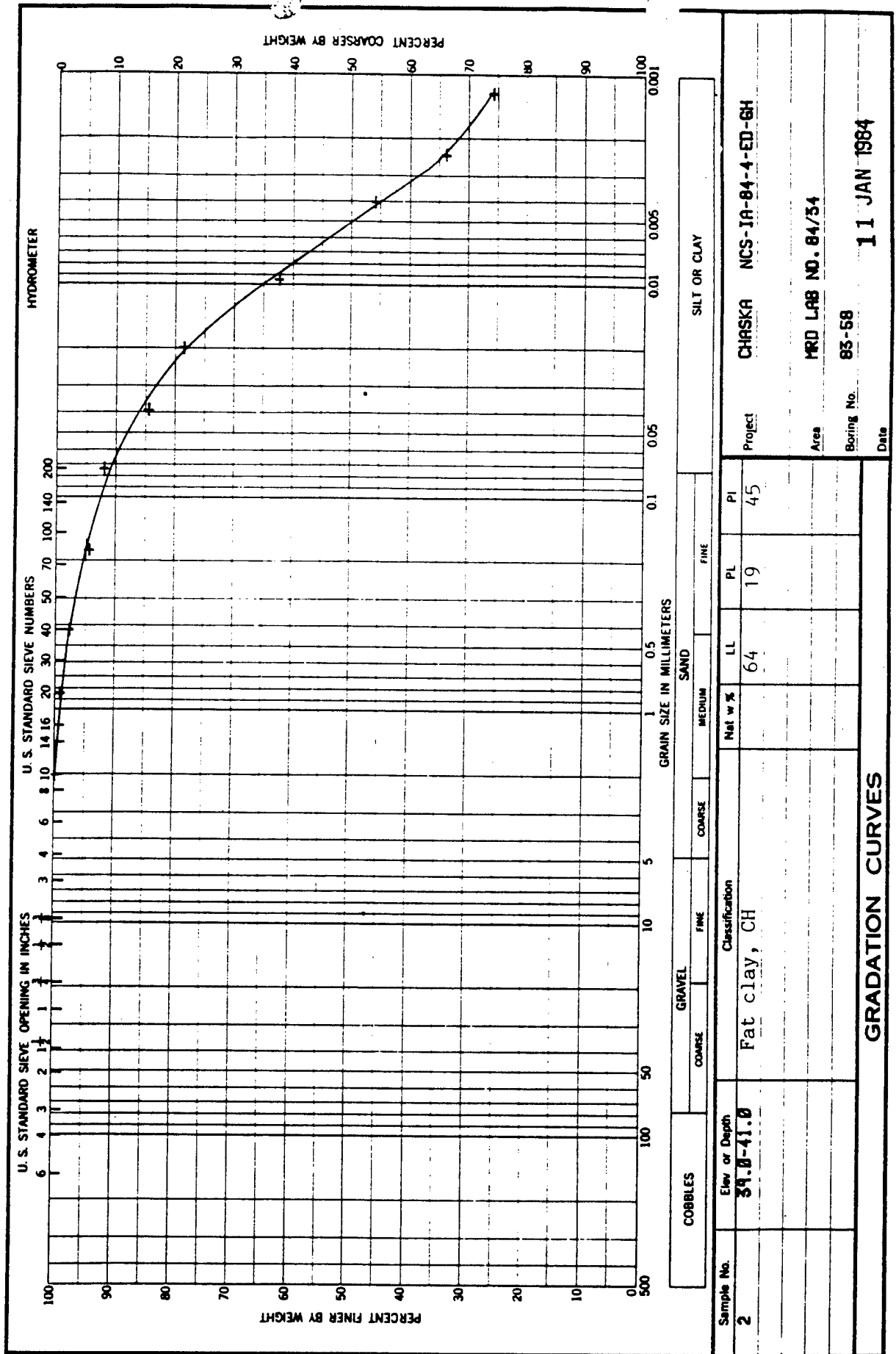
FIGURE 7

Figure C-111





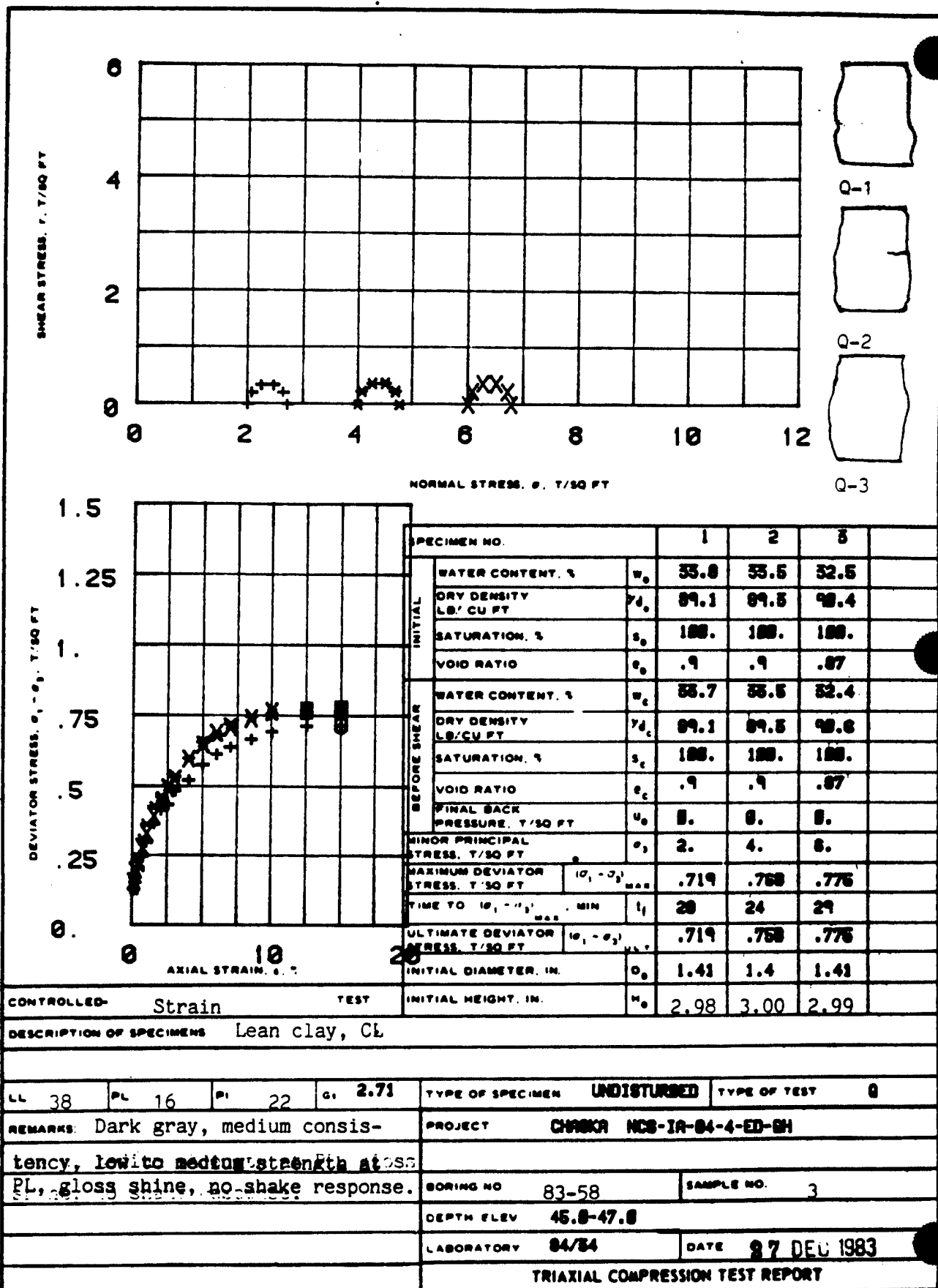




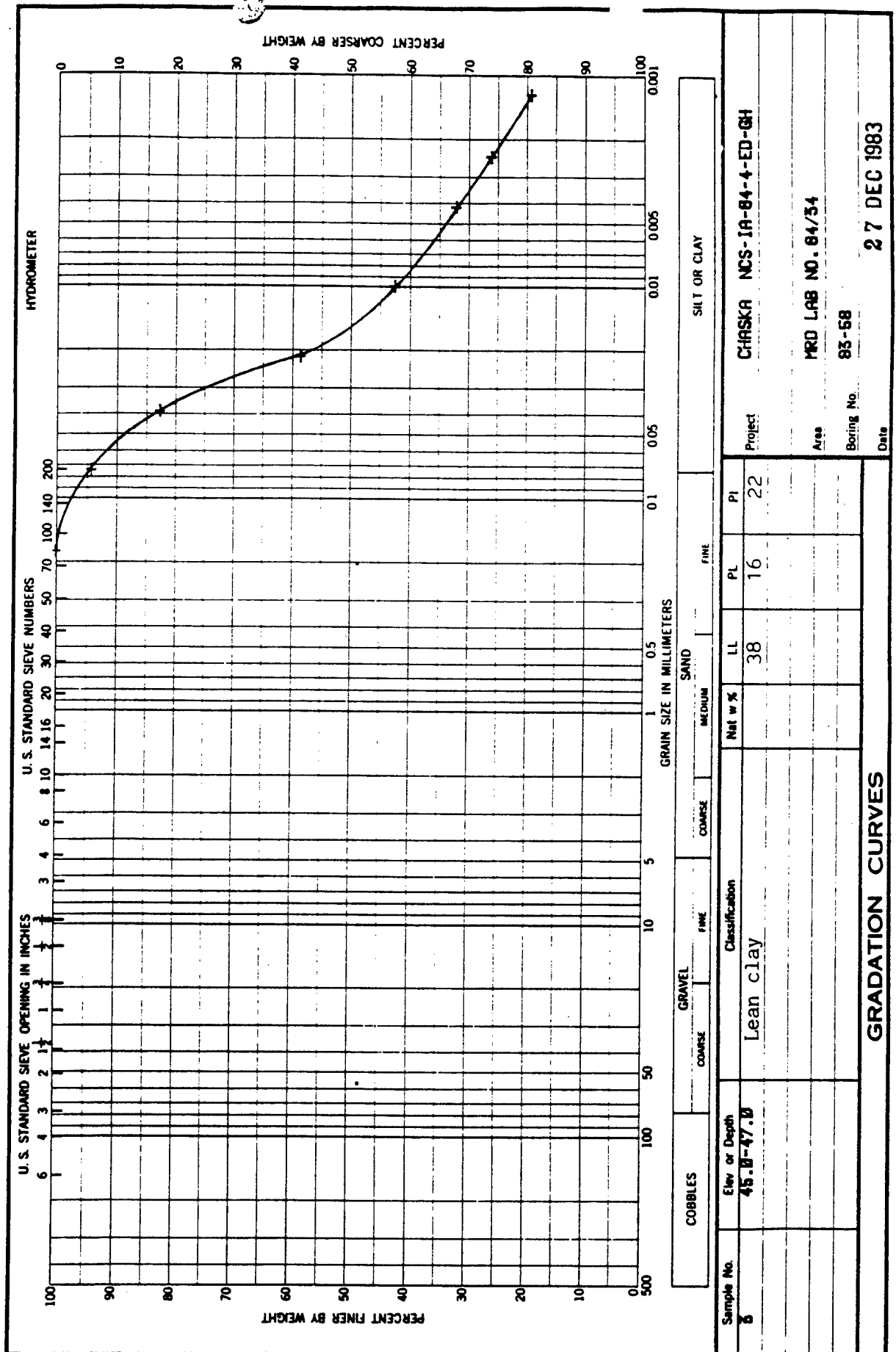
ENG FORM 2087  
1 MAY 63

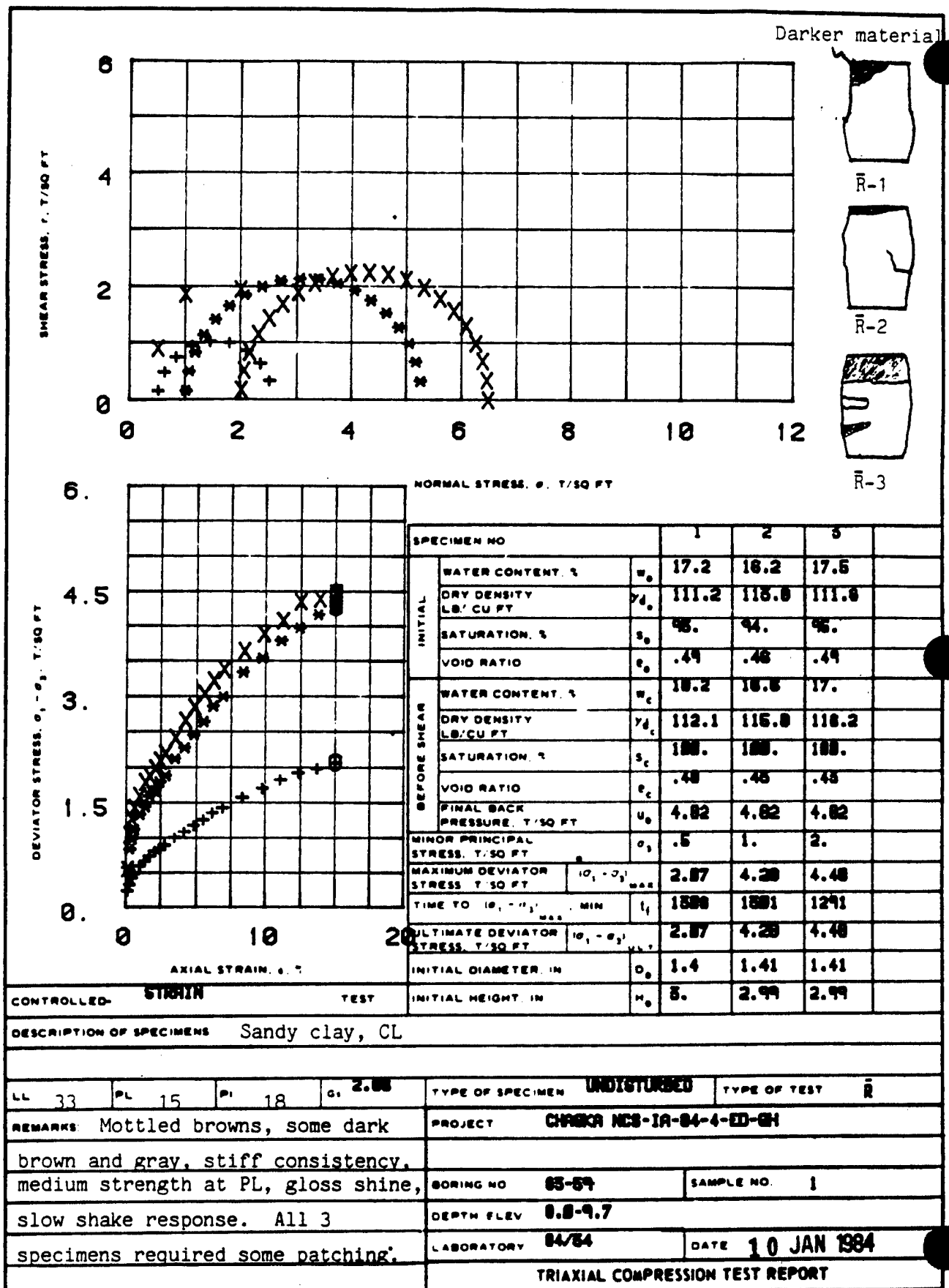
FIGURE 11

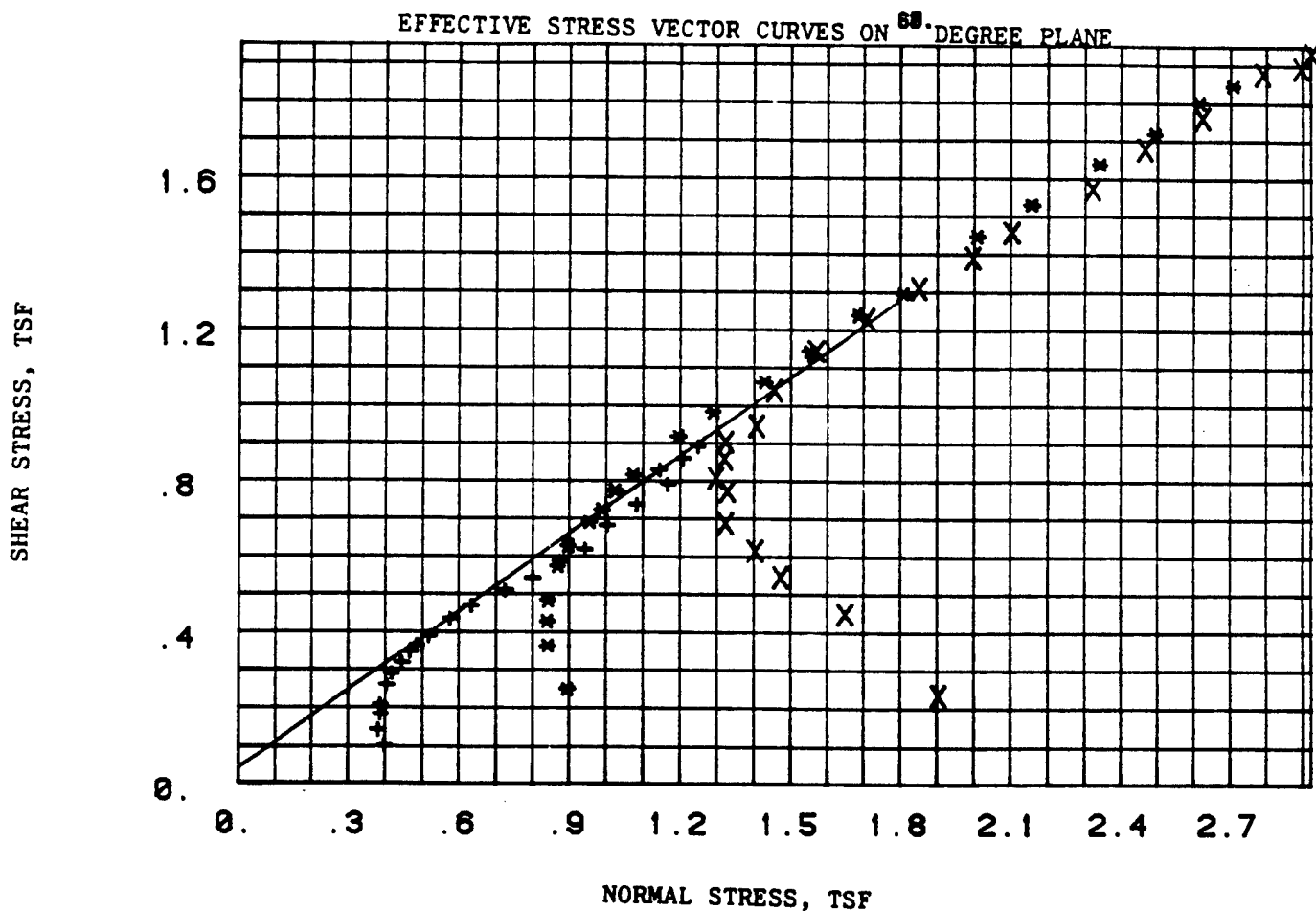
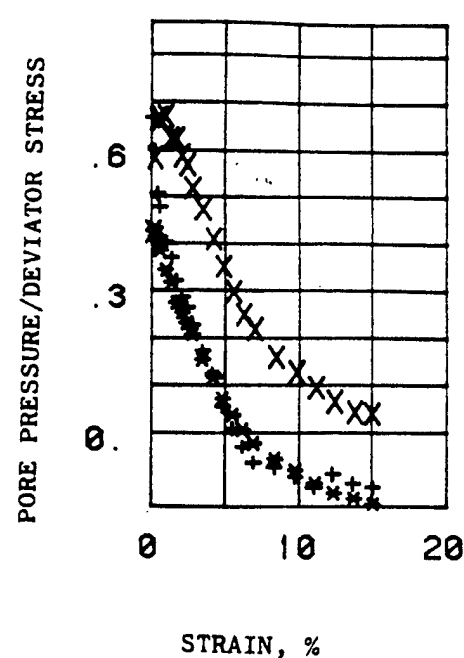
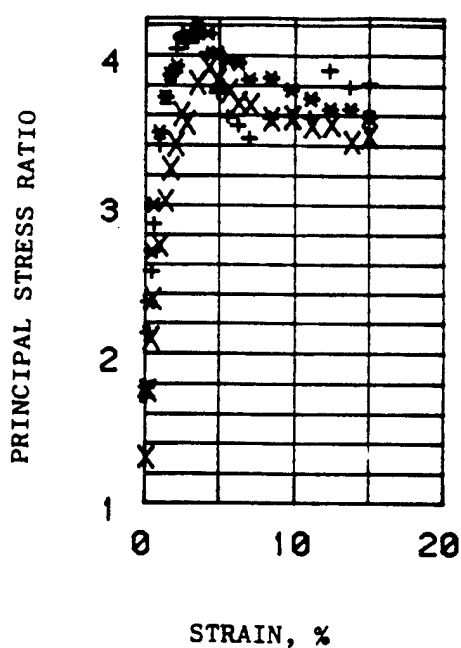
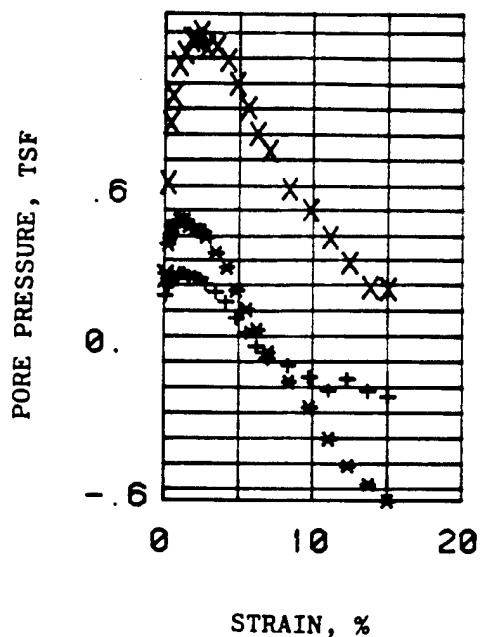
Figure C-115











REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
R TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-84-4-ED-EN  
BORING NO: 83-59 SAMPLE NO: 1  
DEPTH/ELEV: 8.8-9.7  
MRD LAB NO: 84/54 DATE: 10 JAN 1984

TRIAXIAL COMPRESSION TEST REPORT



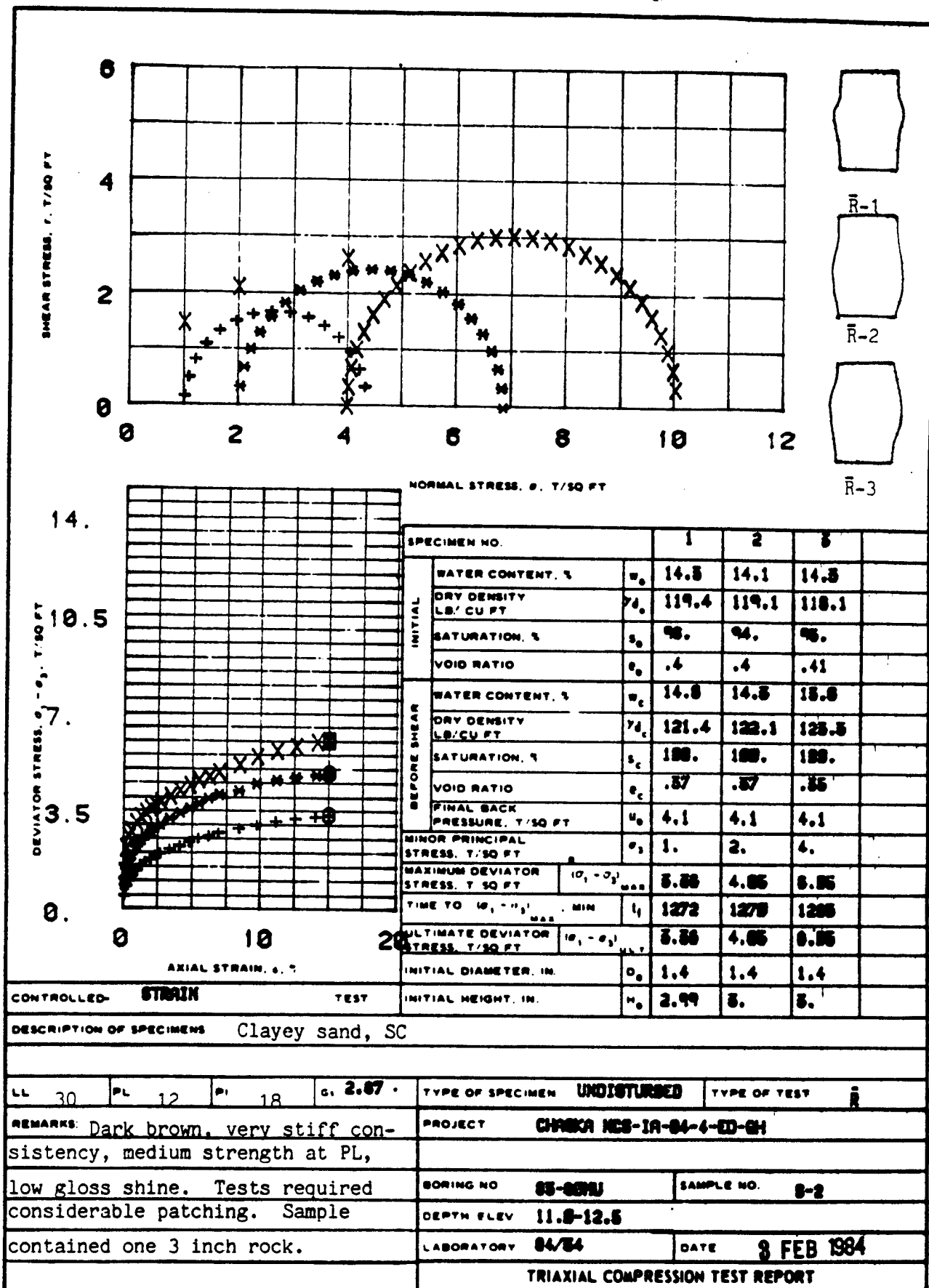
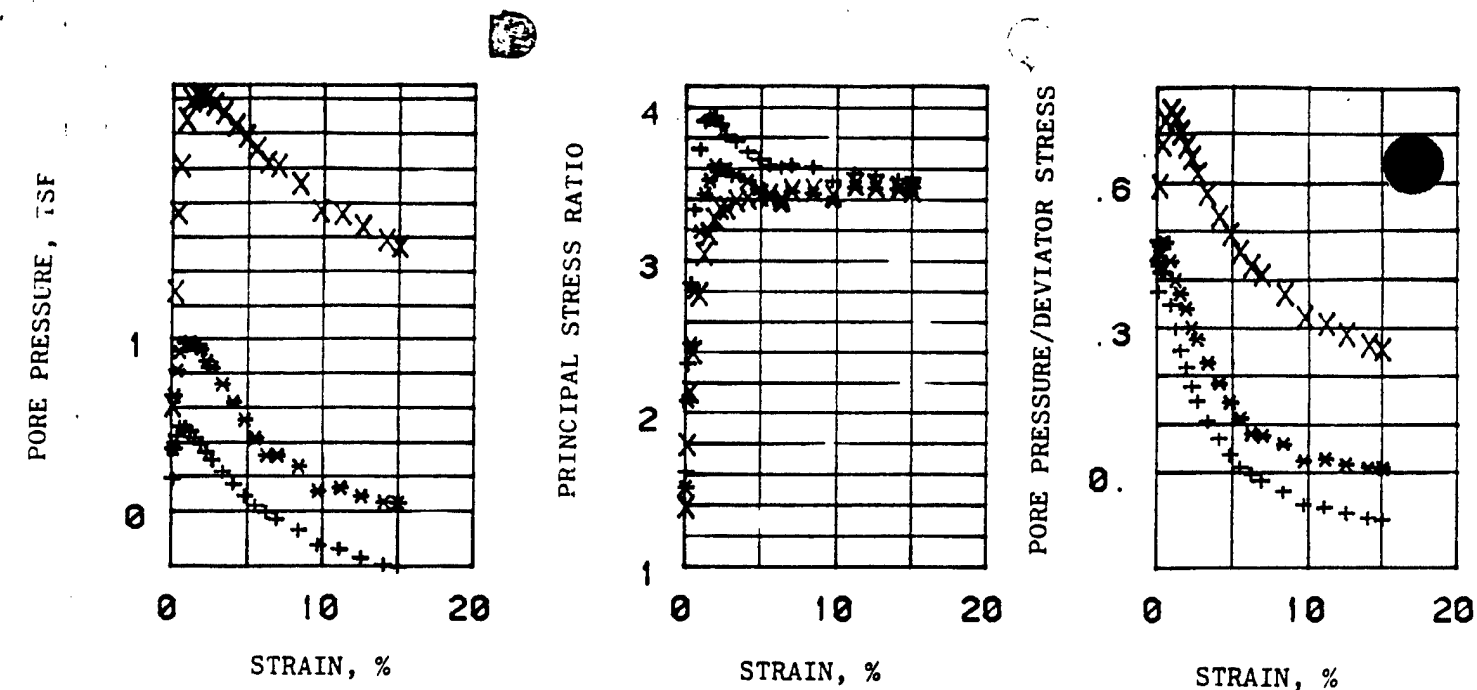
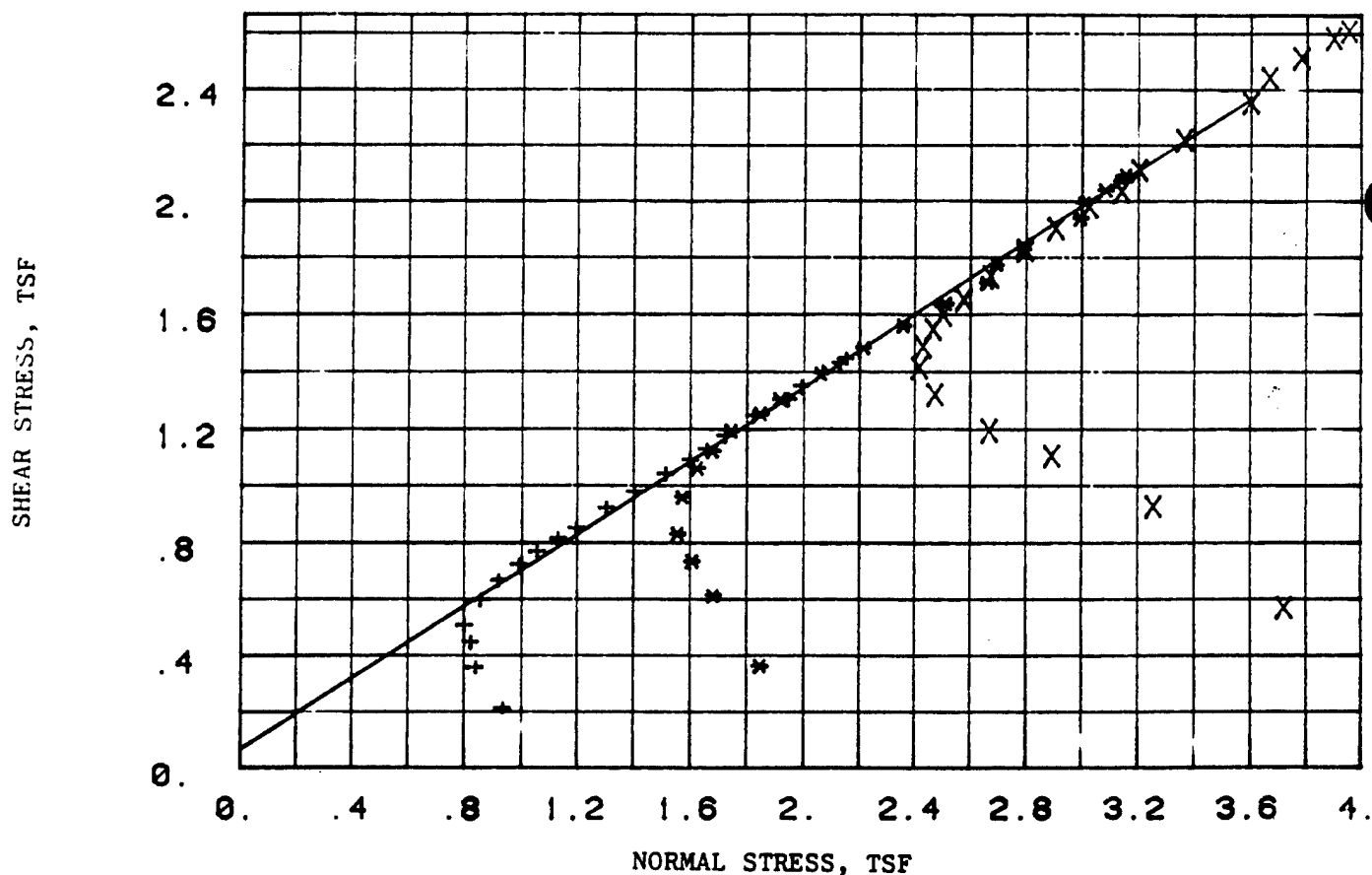


Figure 1



EFFECTIVE STRESS VECTOR CURVES ON  $60^\circ$  DEGREE PLANE



REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
R TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-84-4-ED-6H  
BORING NO: 85-024J  
DEPTH/ELEV: 11.5-12.5  
MRD LAB NO: 84/54  
SAMPLE NO: 8-  
DATE: 3 FEB 1984

TRIAXIAL COMPRESSION TEST REPORT

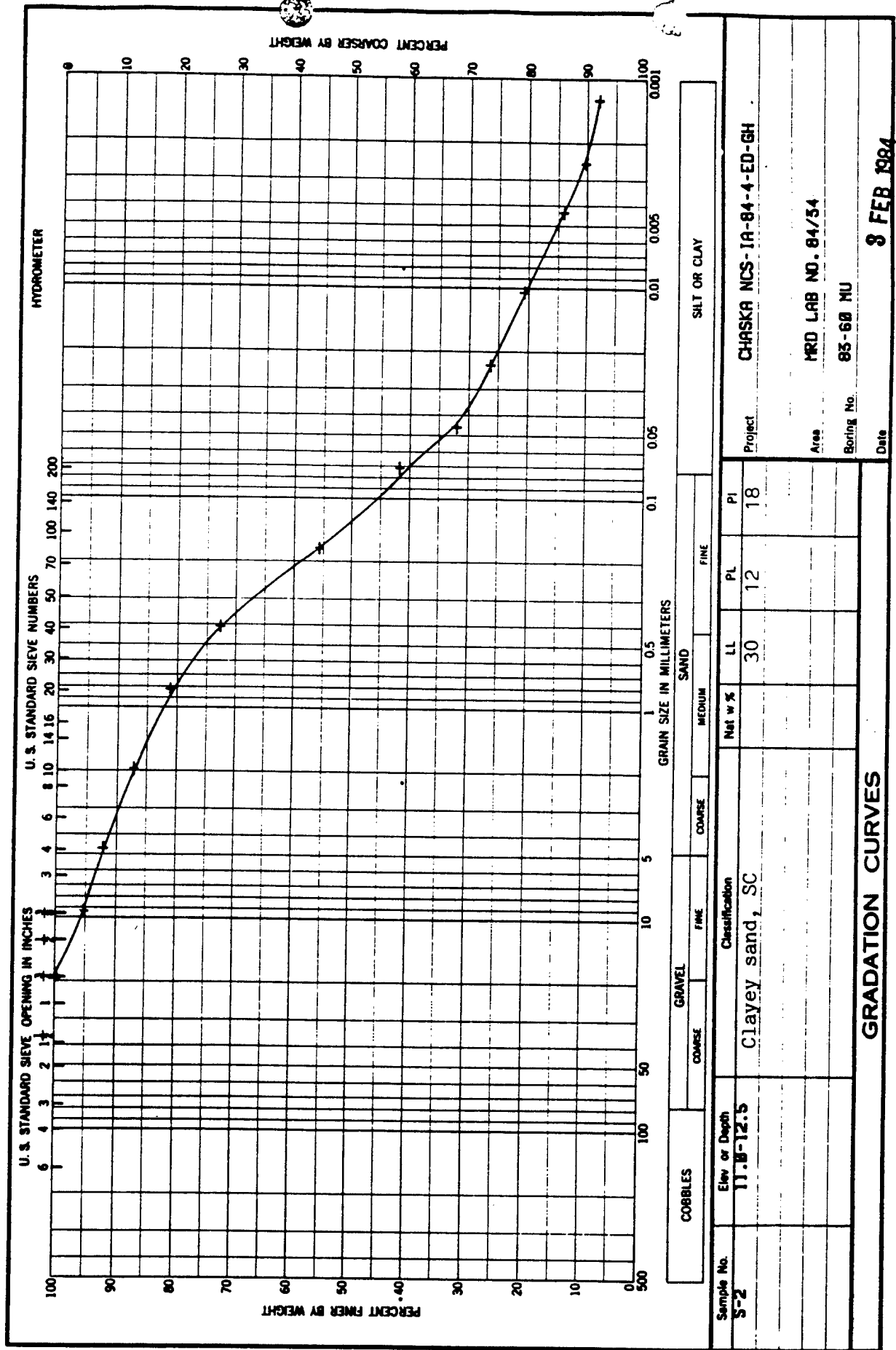
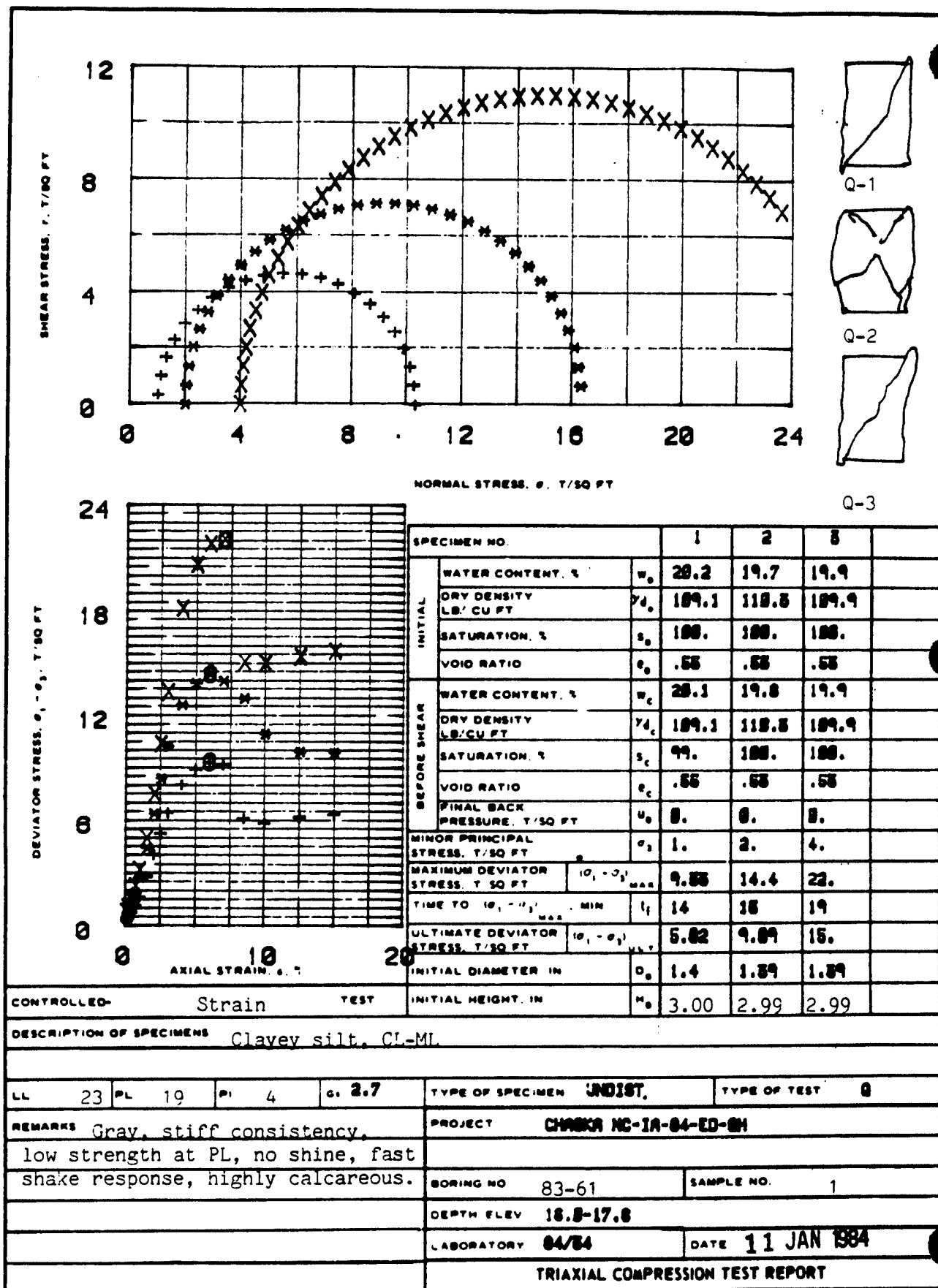
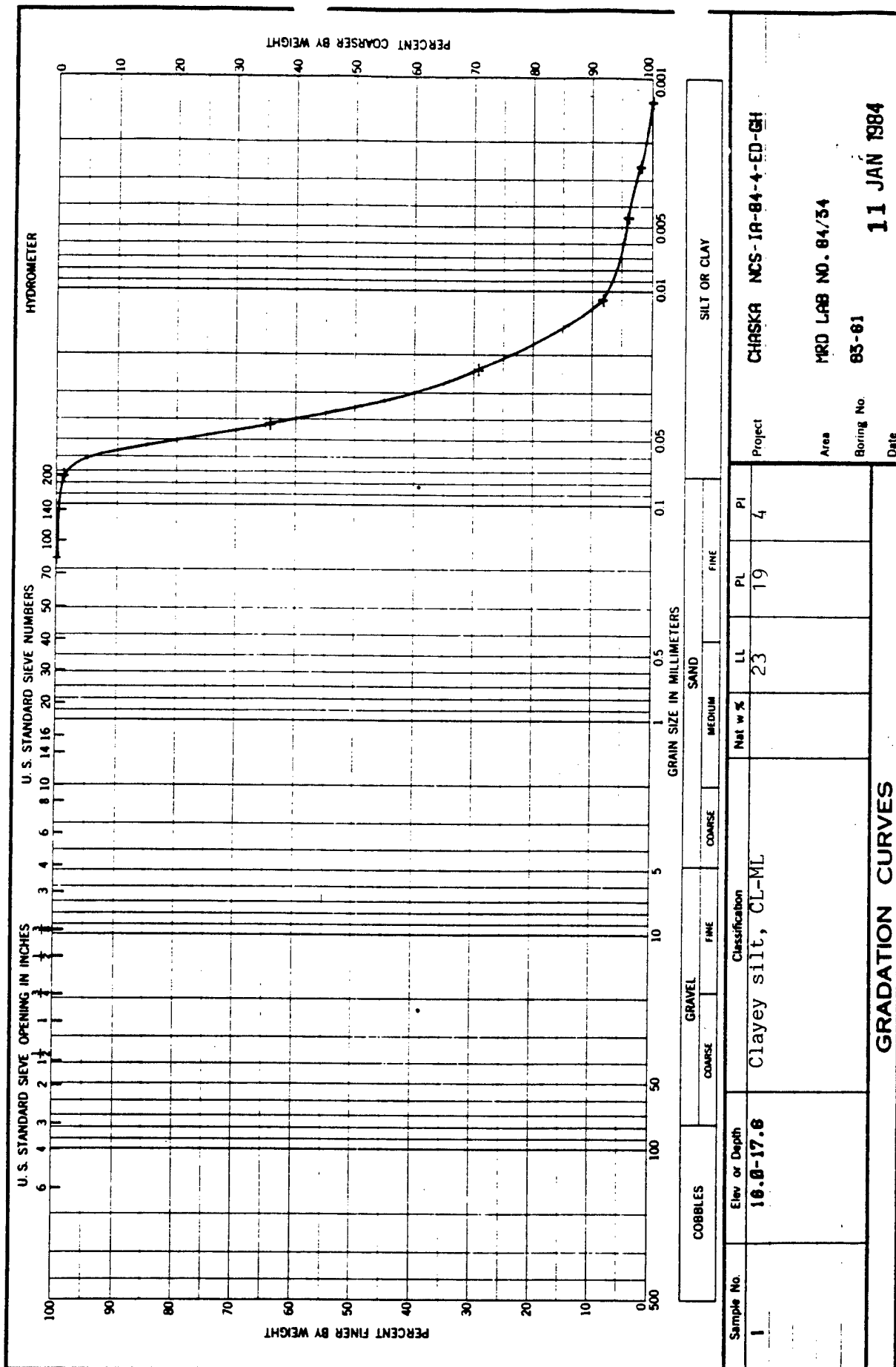


FIGURE 3

ENG FORM 2087  
1 MAY 83

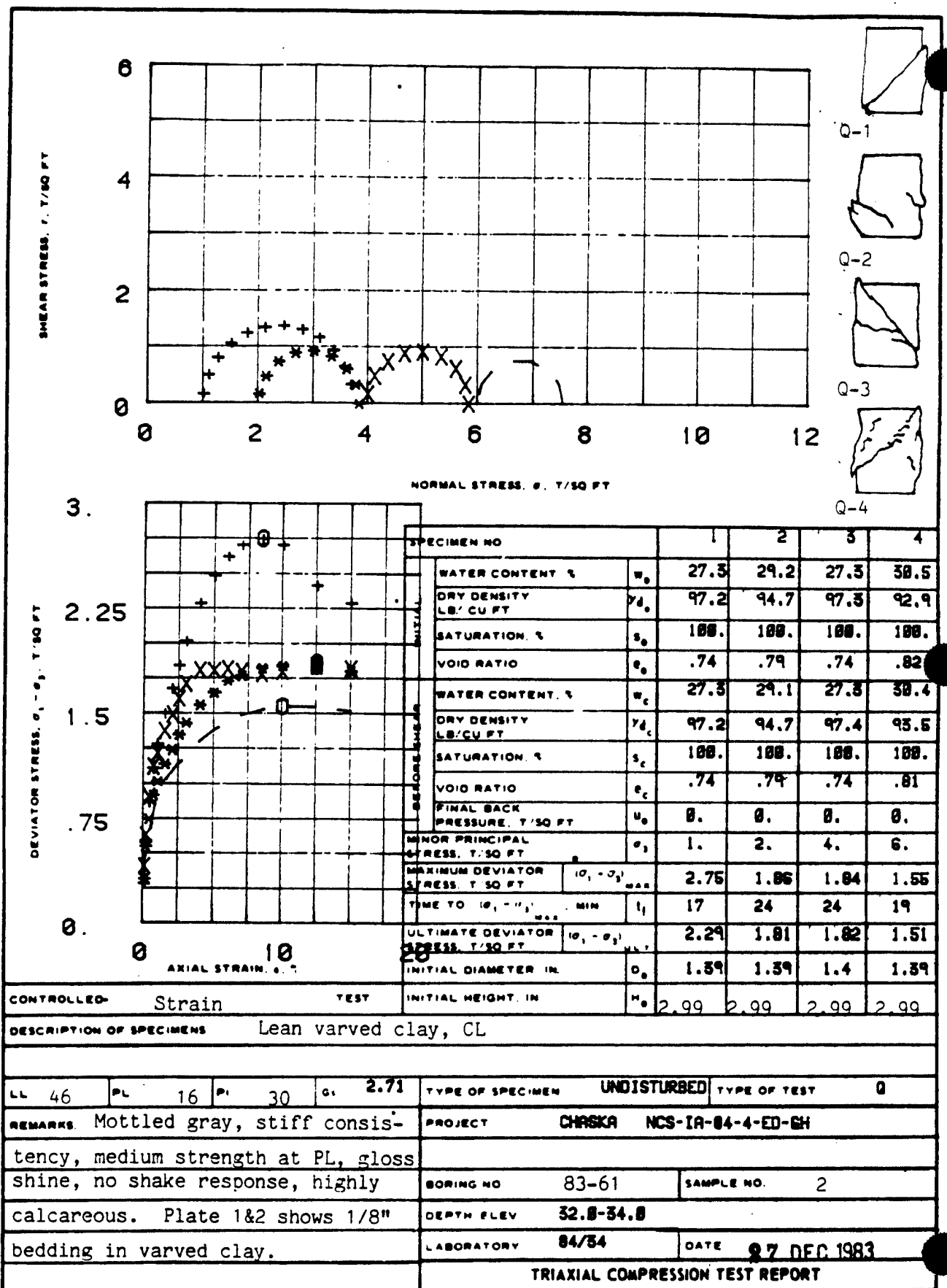


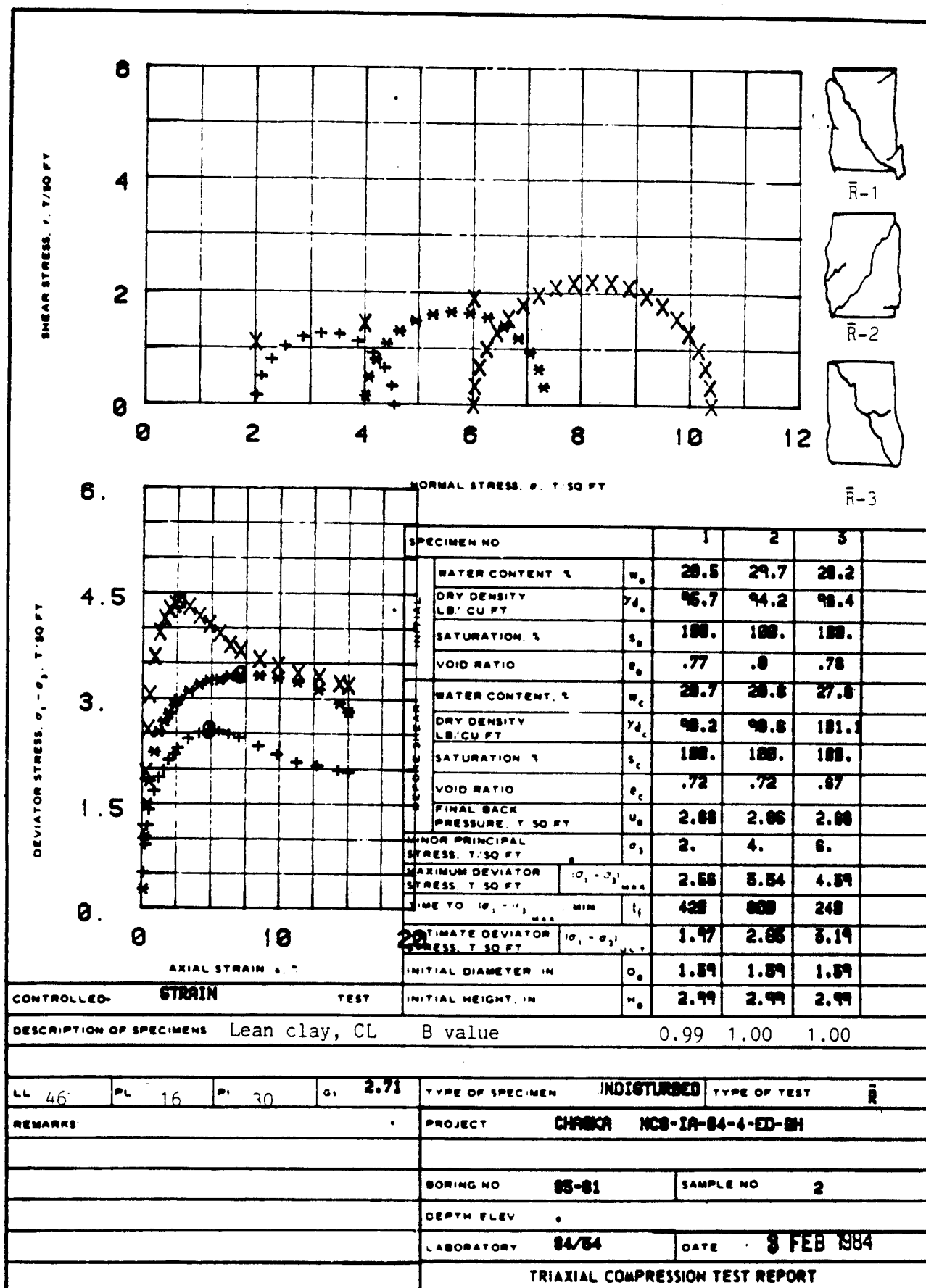


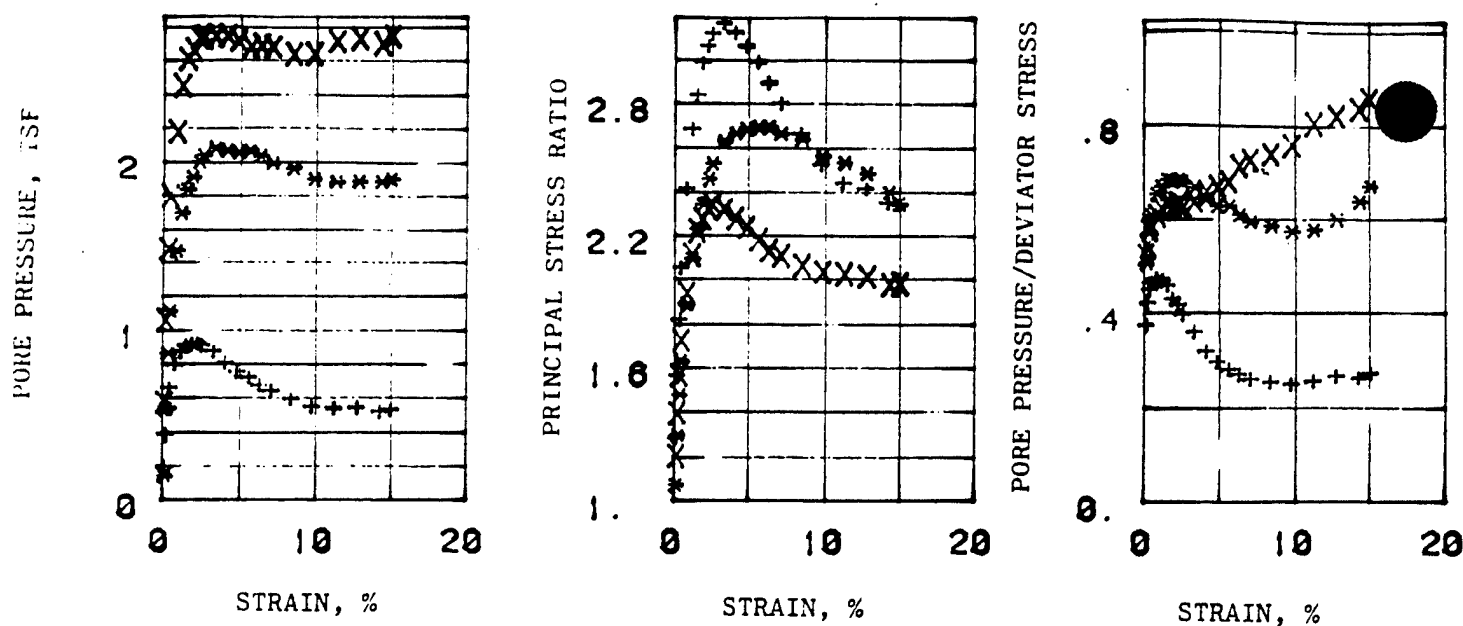


ENG FORM 2087  
1 MAY 63

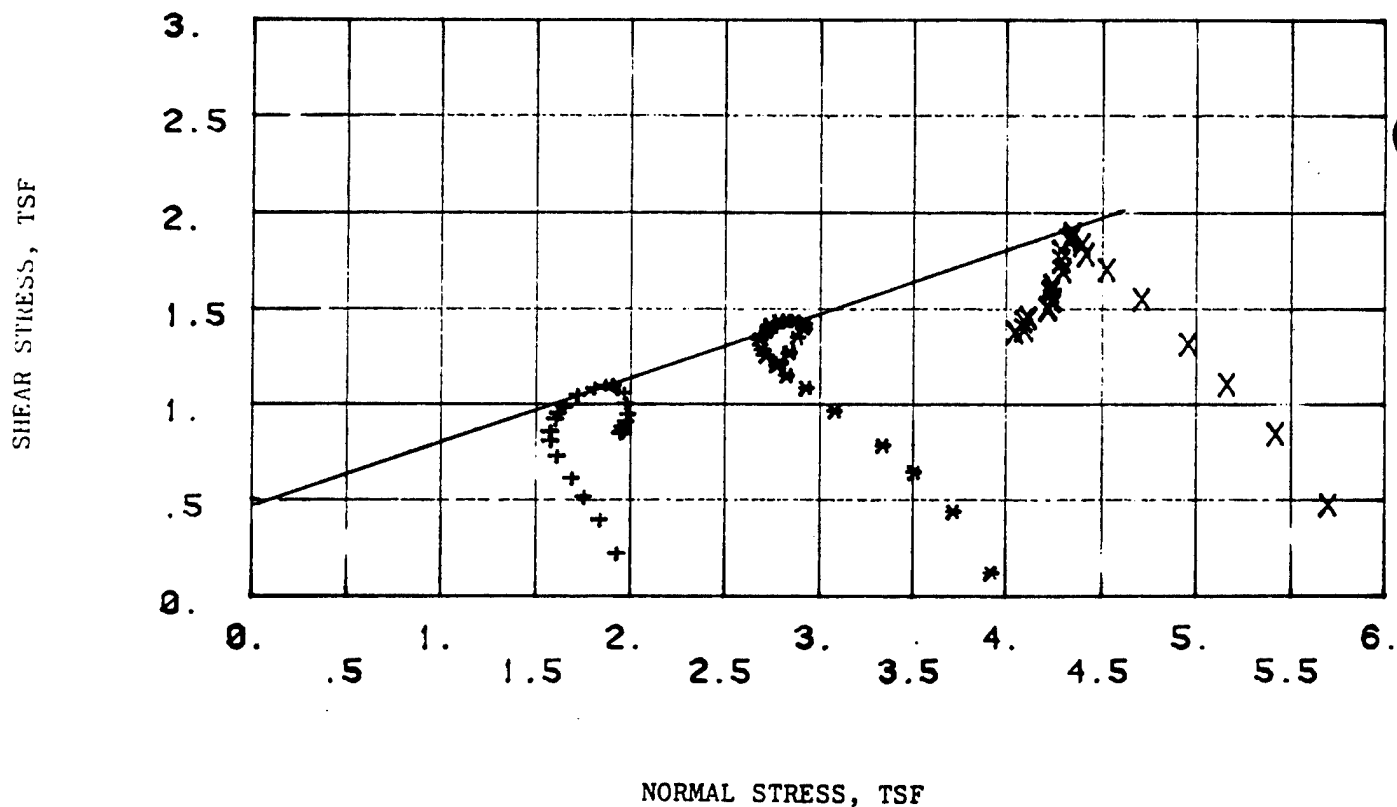
Figure C-125







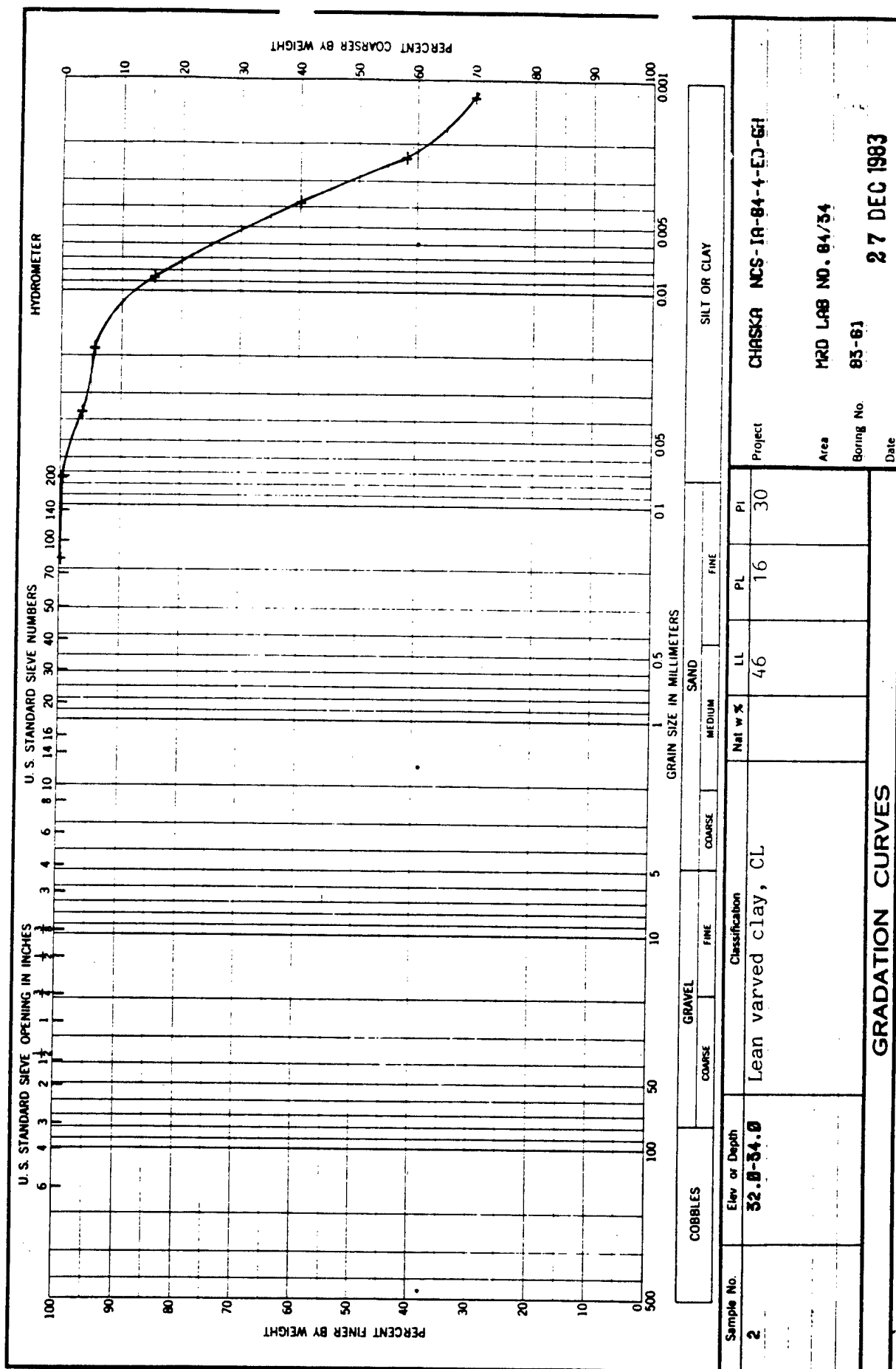
EFFECTIVE STRESS VECTOR CURVES ON  $\sigma_1$  DEGREE PLANE



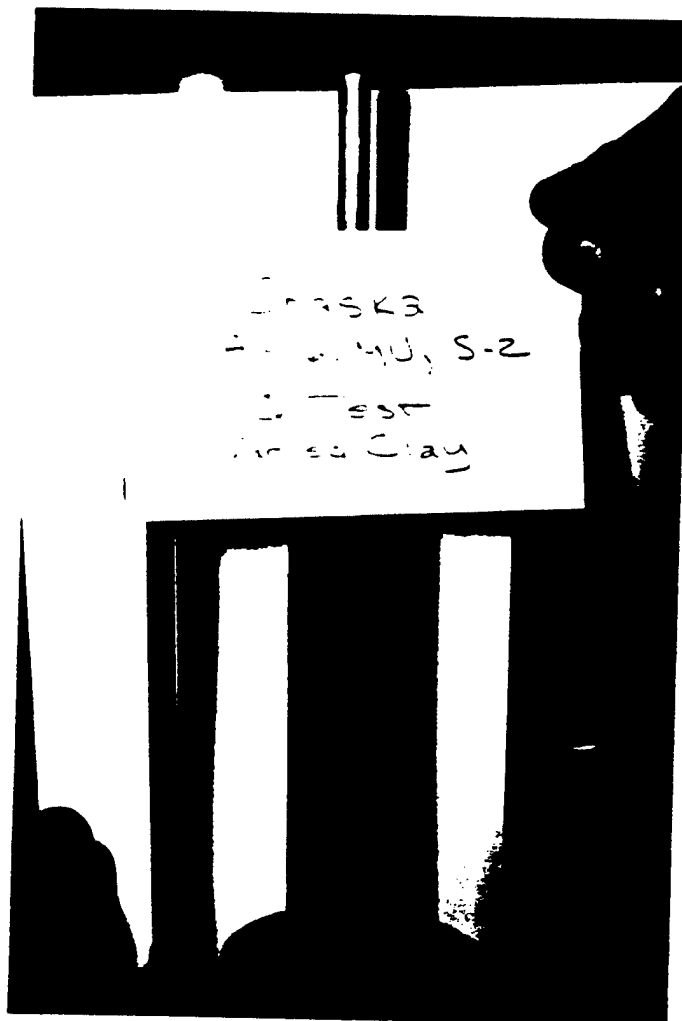
REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-84-4-ED-6H  
BORING NO: 85-81 SAMPLE NO: 2  
DEPTH/ELEV: 84/34 DATE: 8 FEB 1984  
MRD LAB NO:

TRIAXIAL COMPRESSION TEST REPORT



Missouri River Division, Corps of Engineers  
Division Laboratory  
Omaha, Nebraska

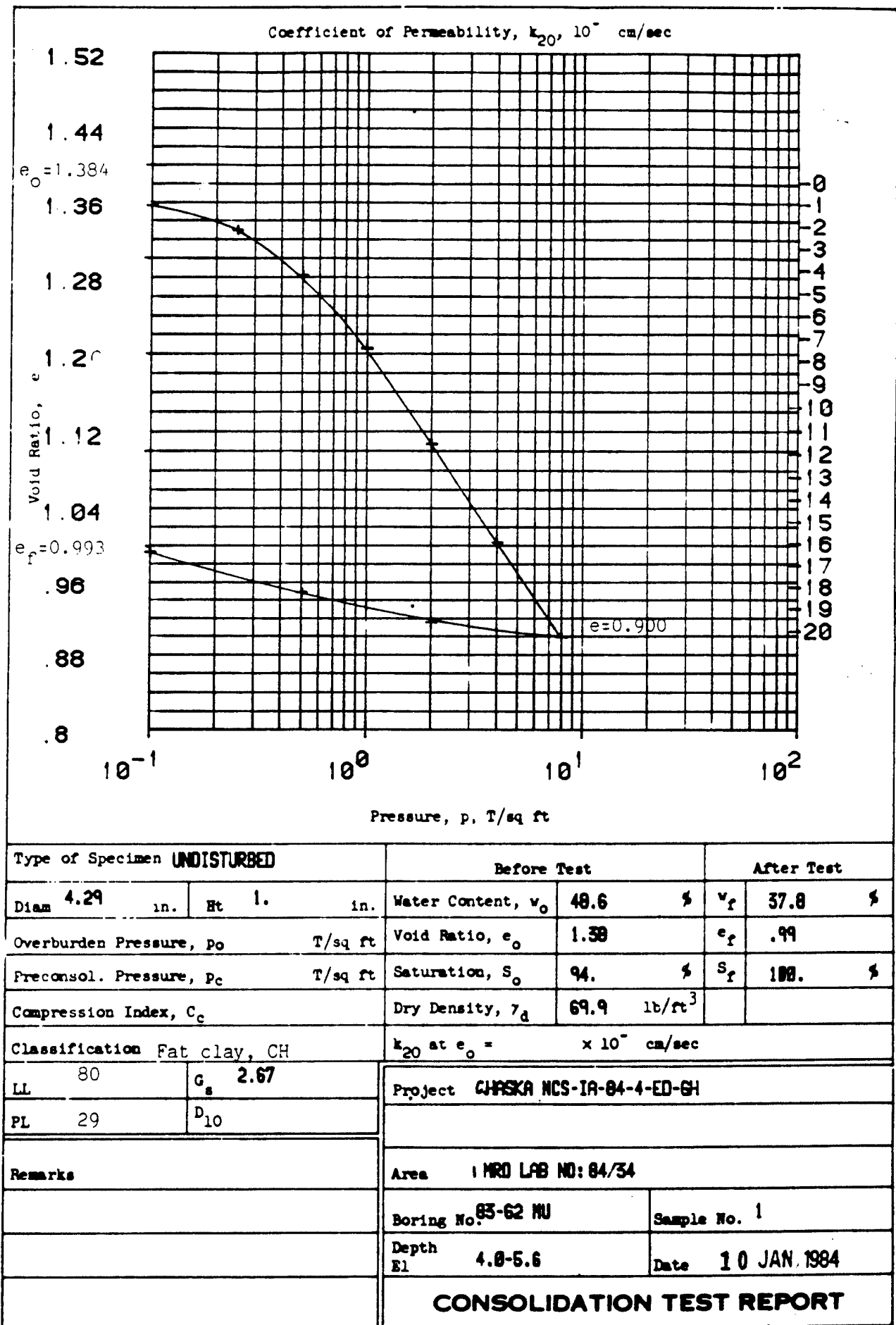


Boring 83-61, Sample 2.  
Bedding fold may indicate insitu slumping.

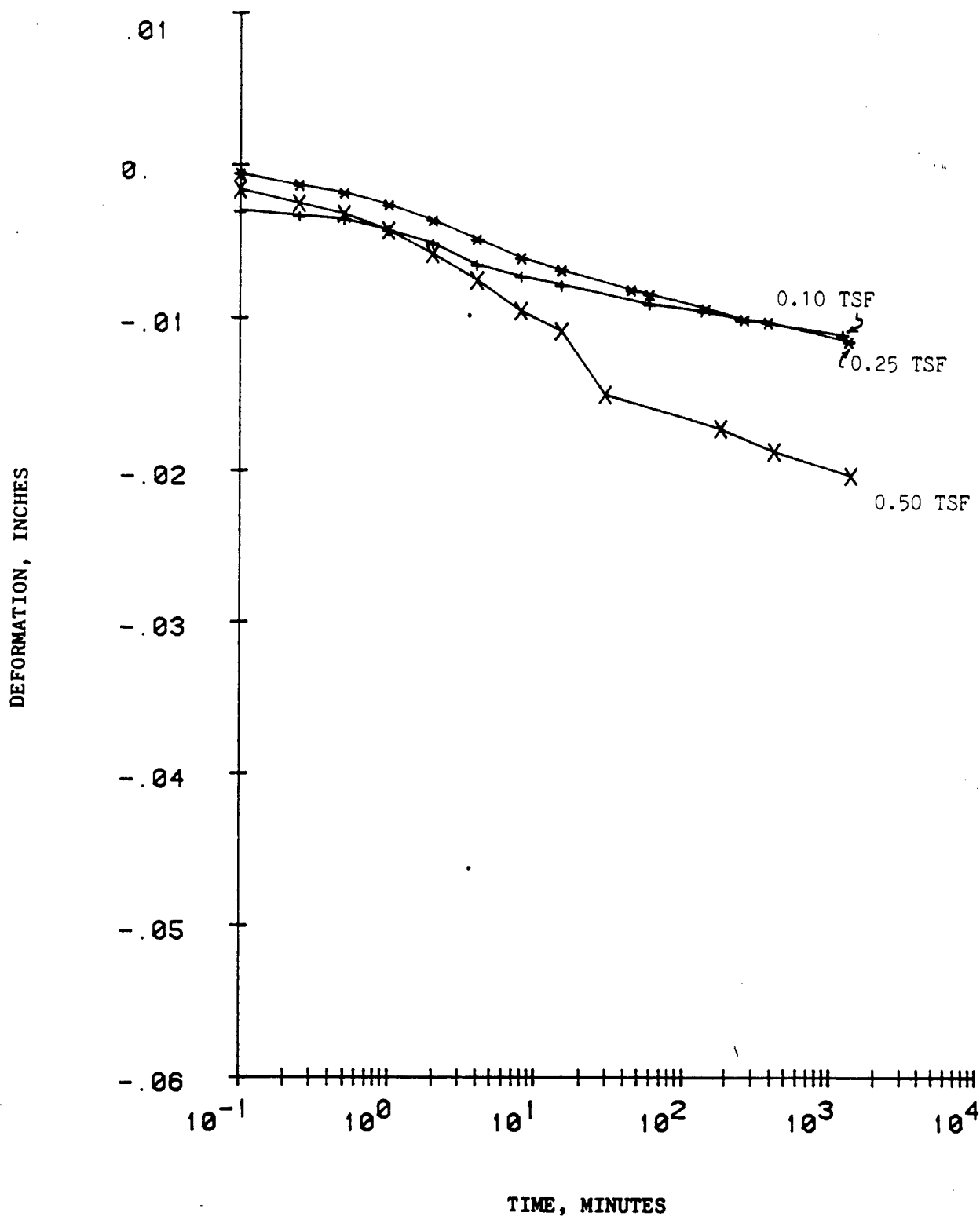
Missouri River Division, Corps of Engineers  
Division Laboratory  
Omaha, Nebraska



Boring, 83-61, Sample 2.  
Bedding fold may indicate insitu slumping.







PROJECT: CHASKA NCS-1A-04-4-ED-6H

MRD LAB NO: 84/34

DATE: 10 JAN 1984

BORING NO: 85-62 MU

SAMPLE NO: 1

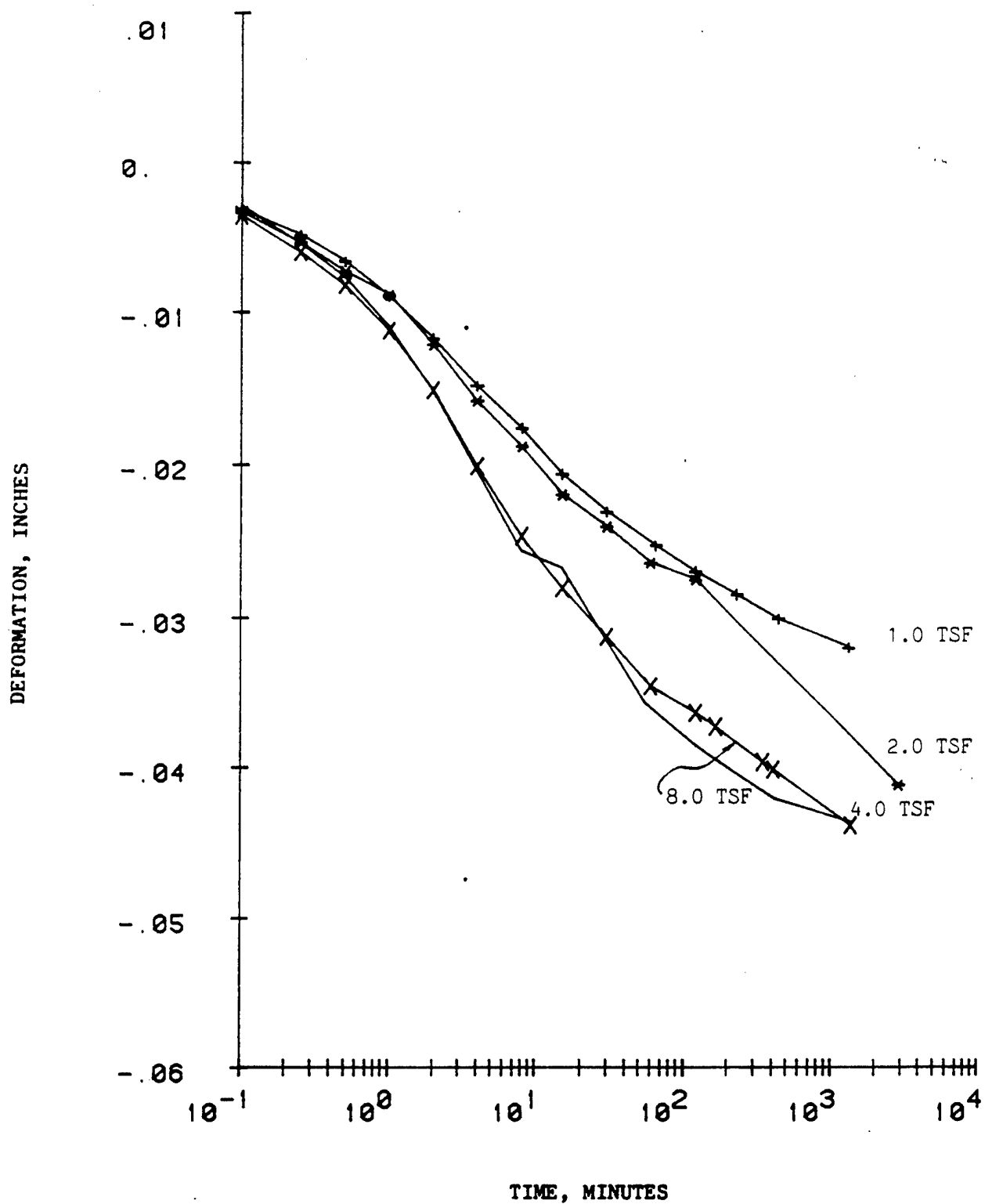
DEPTH/ELEV: 4.0-5.6

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 12

Figure C-133



PROJECT: CHASKA NCS-IA-84-4-ED-6H

MRD LAB NO: 84/34

DATE: 10 JAN 1984

BORING NO: 83-62 MU

SAMPLE NO: 1

DEPTH/ELEV: 4.8-5.6

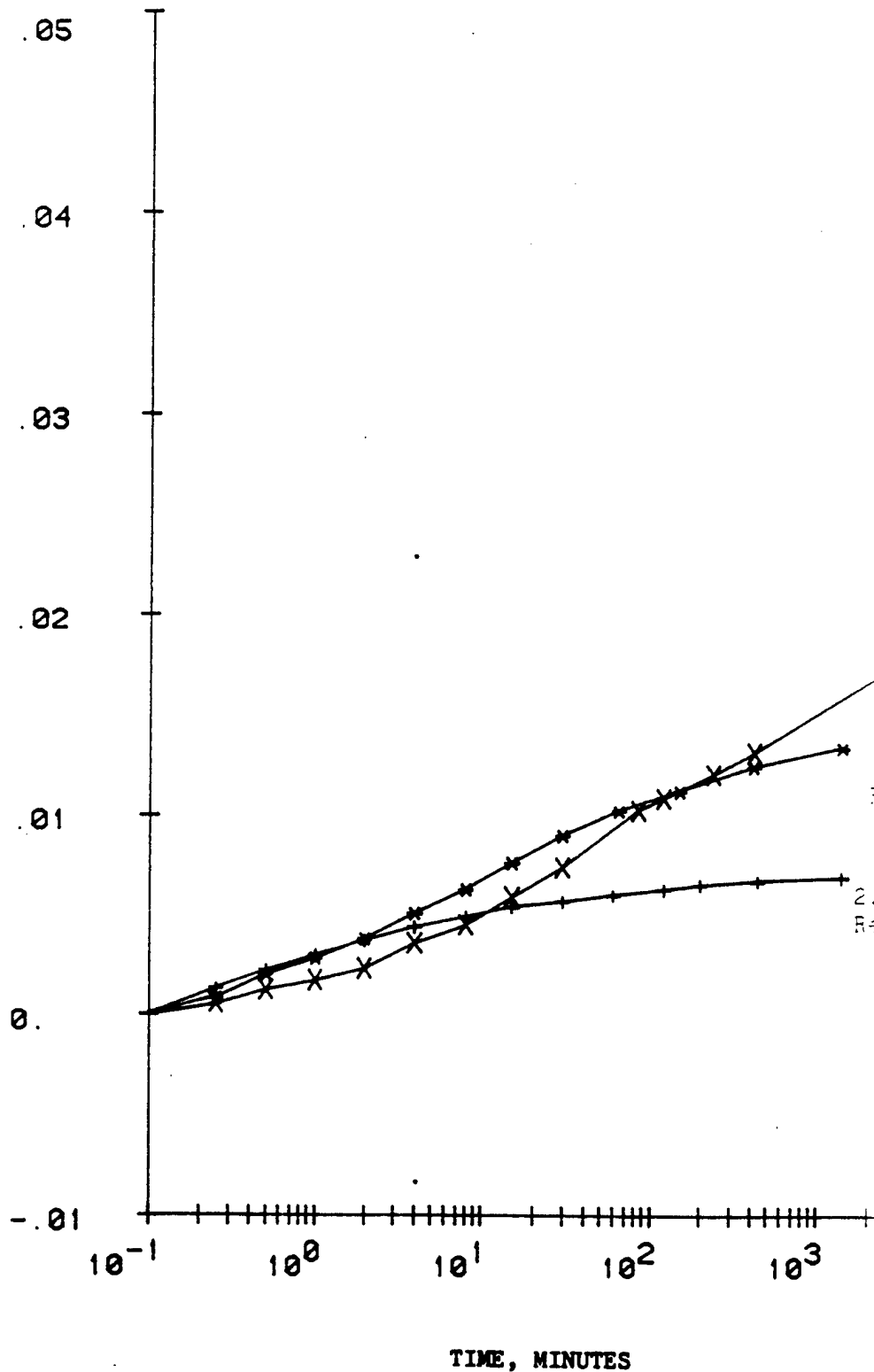
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 13

Figure C-134

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-84-4-ED-6H

MRD LAB NO: 84/34

DATE: 10 JAN 85

BORING NO: 85-62 MU

SAMPLE NO: 1

DEPTH/ELEV: 4.8-

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CUR

FIGURE: 14

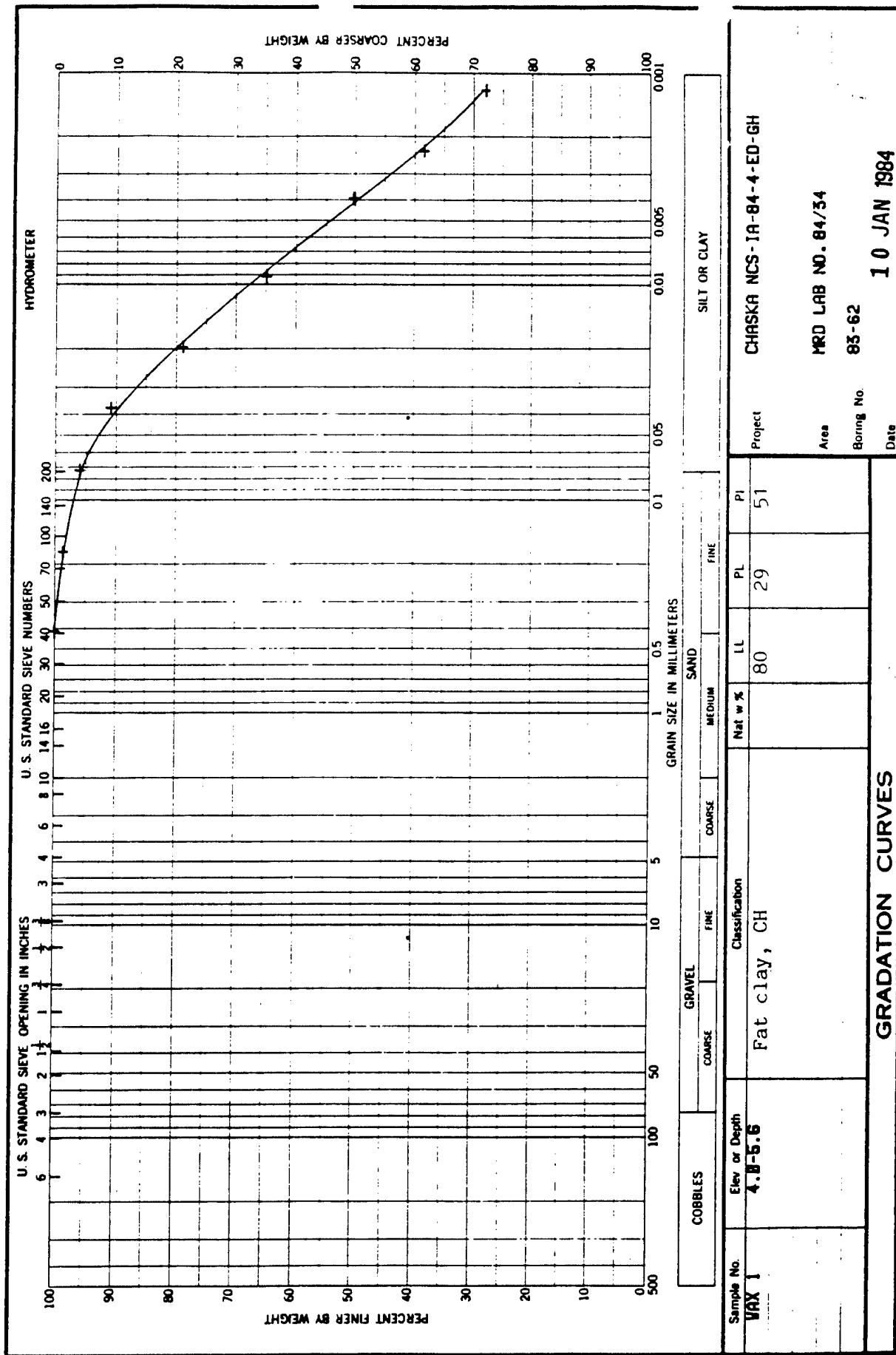
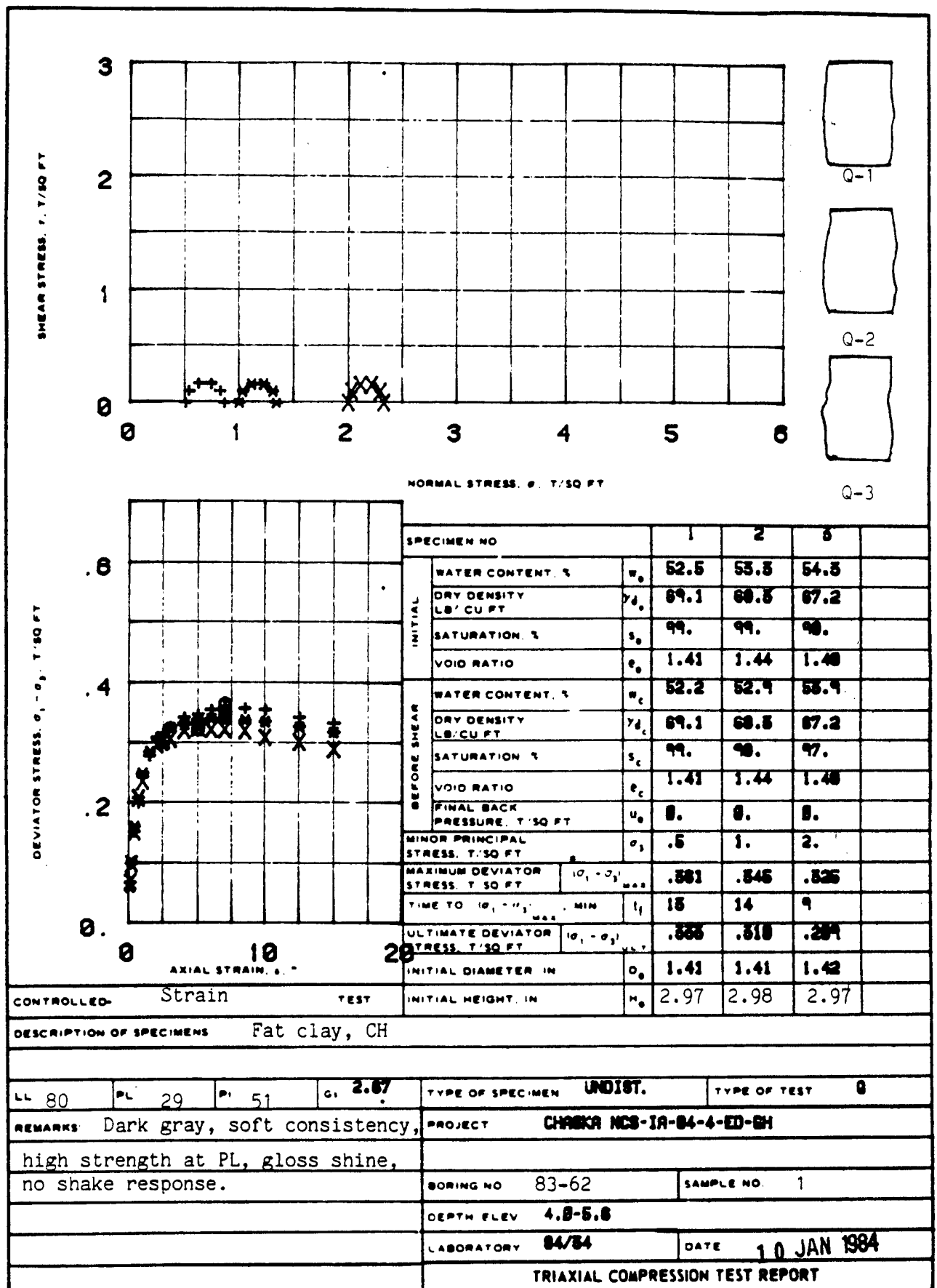
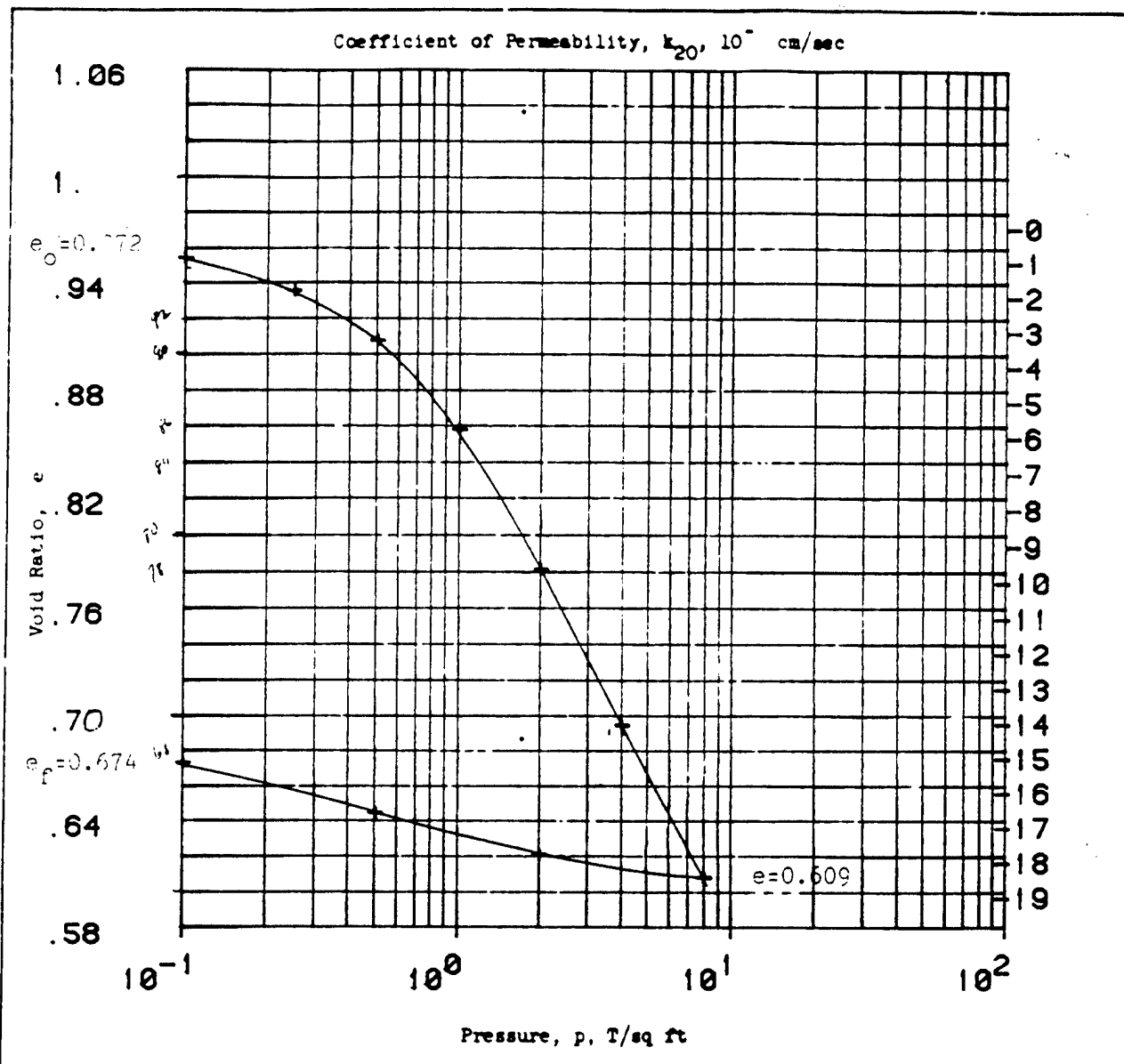


FIGURE 15

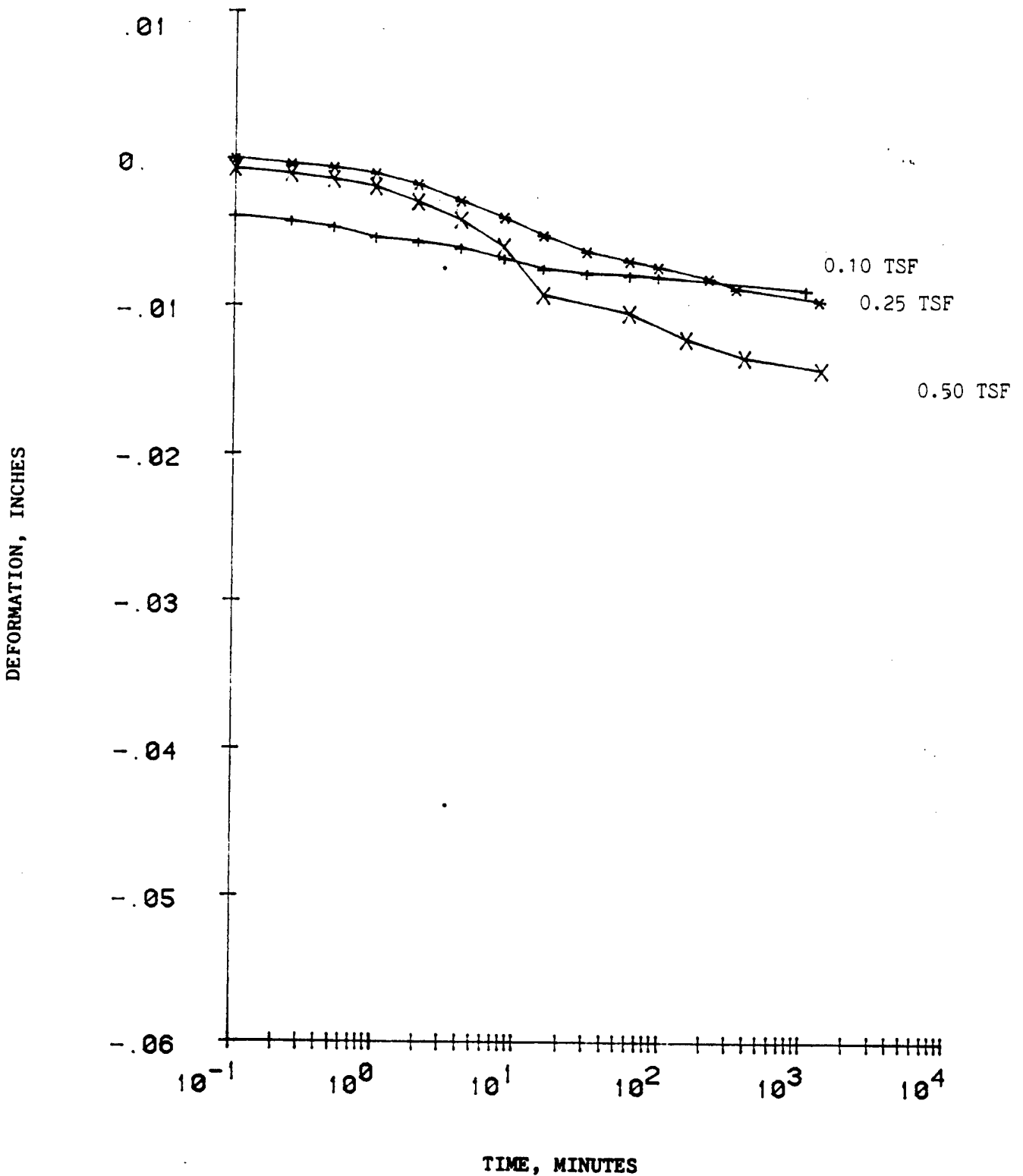
ENG FORM 1 MAY 63 2087

Figure C-136





Type of Specimen <b>UNDISTURBED</b>		Before Test		After Test	
Diam 4.29 in.	Ht 1. in.	Water Content, $w_o$	35.8 %	$w_f$	24.8 %
Overburden Pressure, $p_o$	T/sq ft	Void Ratio, $e_o$	.97	$e_f$	.67
Preconsol. Pressure, $p_c$	T/sq ft	Saturation, $S_o$	98. %	$S_f$	98. %
Compression Index, $C_c$		Dry Density, $\gamma_d$	84.2 lb/ft <sup>3</sup>		
Classification Sandy clay, CL		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL 31	$G_s$ 2.66	Project CHASKA NCS-IA-84-4-ED-6H			
PL 14	$D_{10}$				
Remarks		Area MRD LAB NO: 84/34			
		Boring No. 83-62 MU	Sample No. S-2		
		Depth El 8.8-9.3	Date 8 FEB 1984		
		<b>CONSOLIDATION TEST REPORT</b>			



PROJECT: CHASKA NCS-IA-84-4-ED-6H

MRD LAB NO: 84/34

DATE: 3 FEB 1984

BORING NO: 85-62 MU

SAMPLE NO: S-2

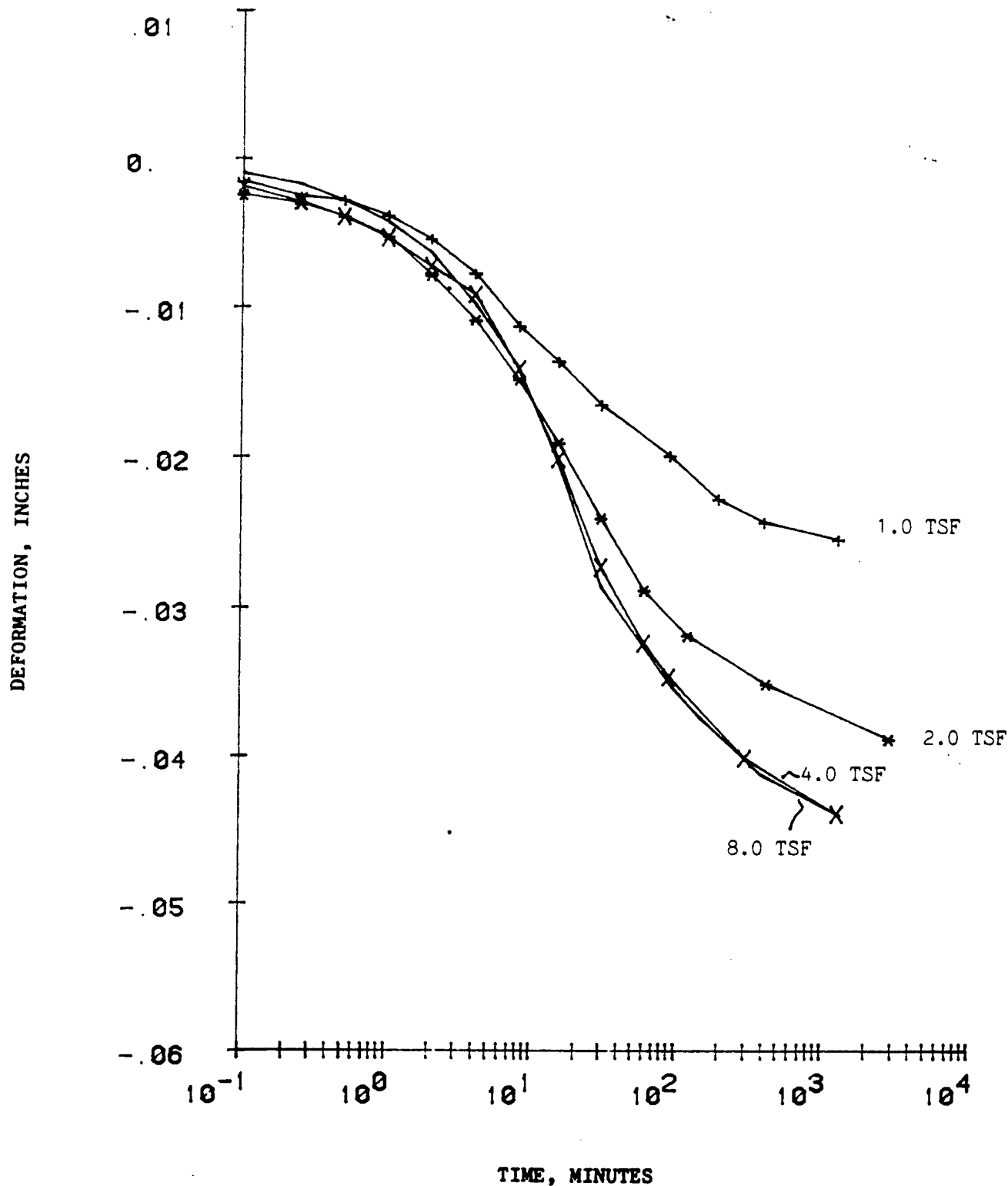
DEPTH/ELEV: 8.8-9.3

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 9

Figure C-139



PROJECT: CHASKA NCS-1A-84-4-ED-6H

MRD LAB NO: 84/34

DATE: 8 FEB 1984

BORING NO: 83-62 MU

SAMPLE NO: S-2

DEPTH/ELEV: 8.8-9.3

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

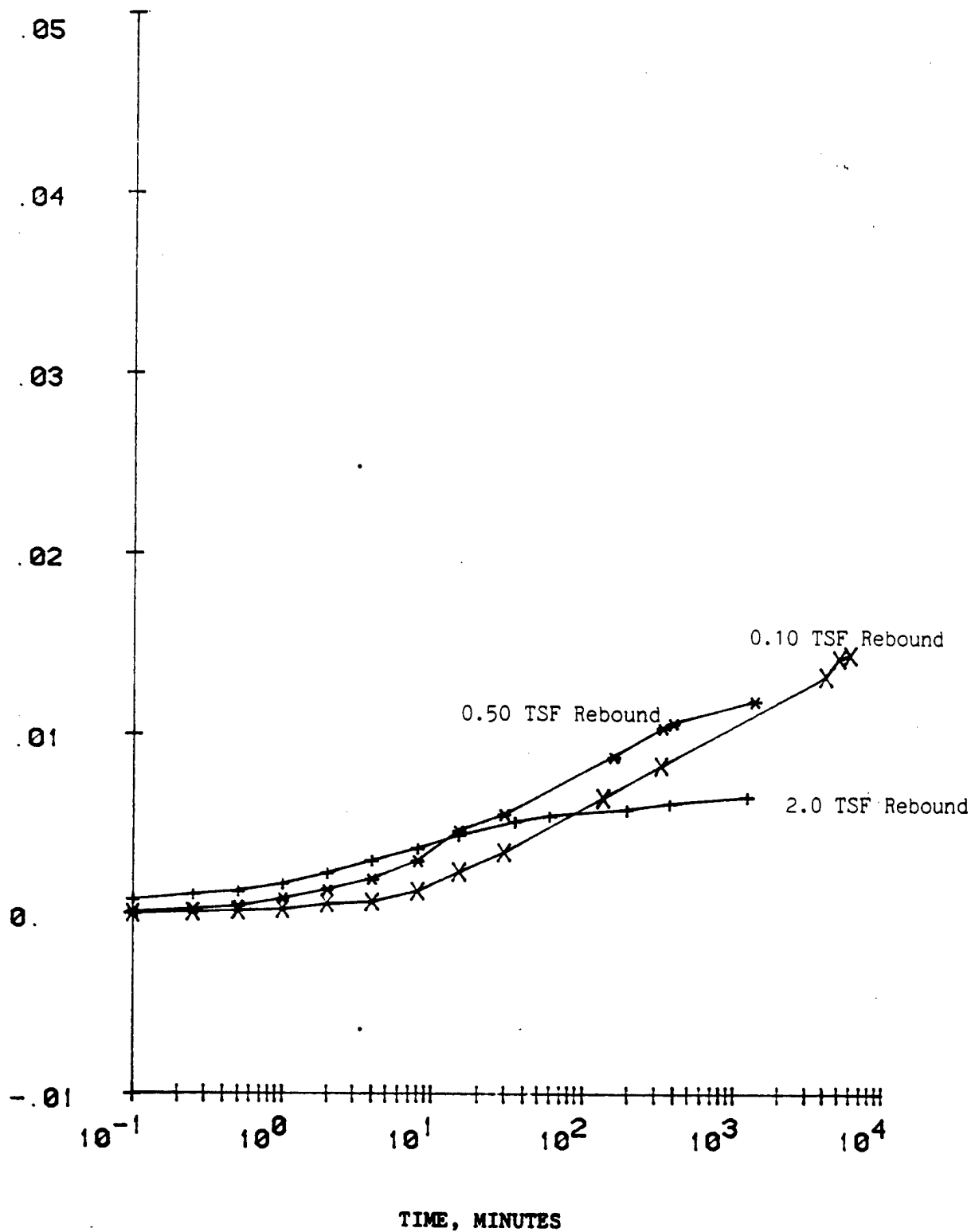
CONSOLIDATION TEST—TIME CURVES

FIGURE: 10

Figure C-140



DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-84-4-ED-6H

MRD LAB NO: 84/34

DATE: 3 FEB 1984

BORING NO: 85-62 MU

SAMPLE NO: S-2

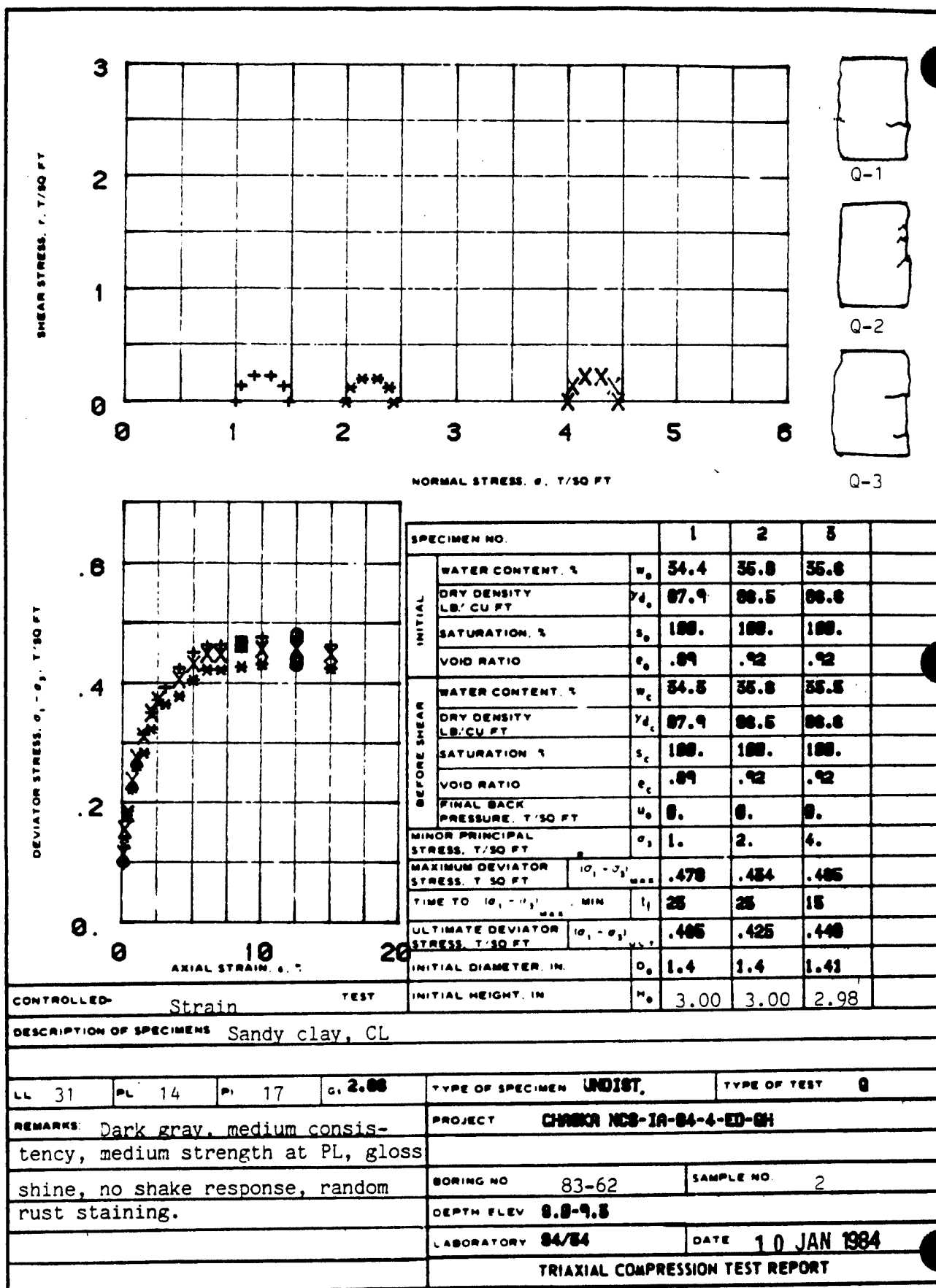
DEPTH/ELEV: 8.8-9.3

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 11

Figure C-141



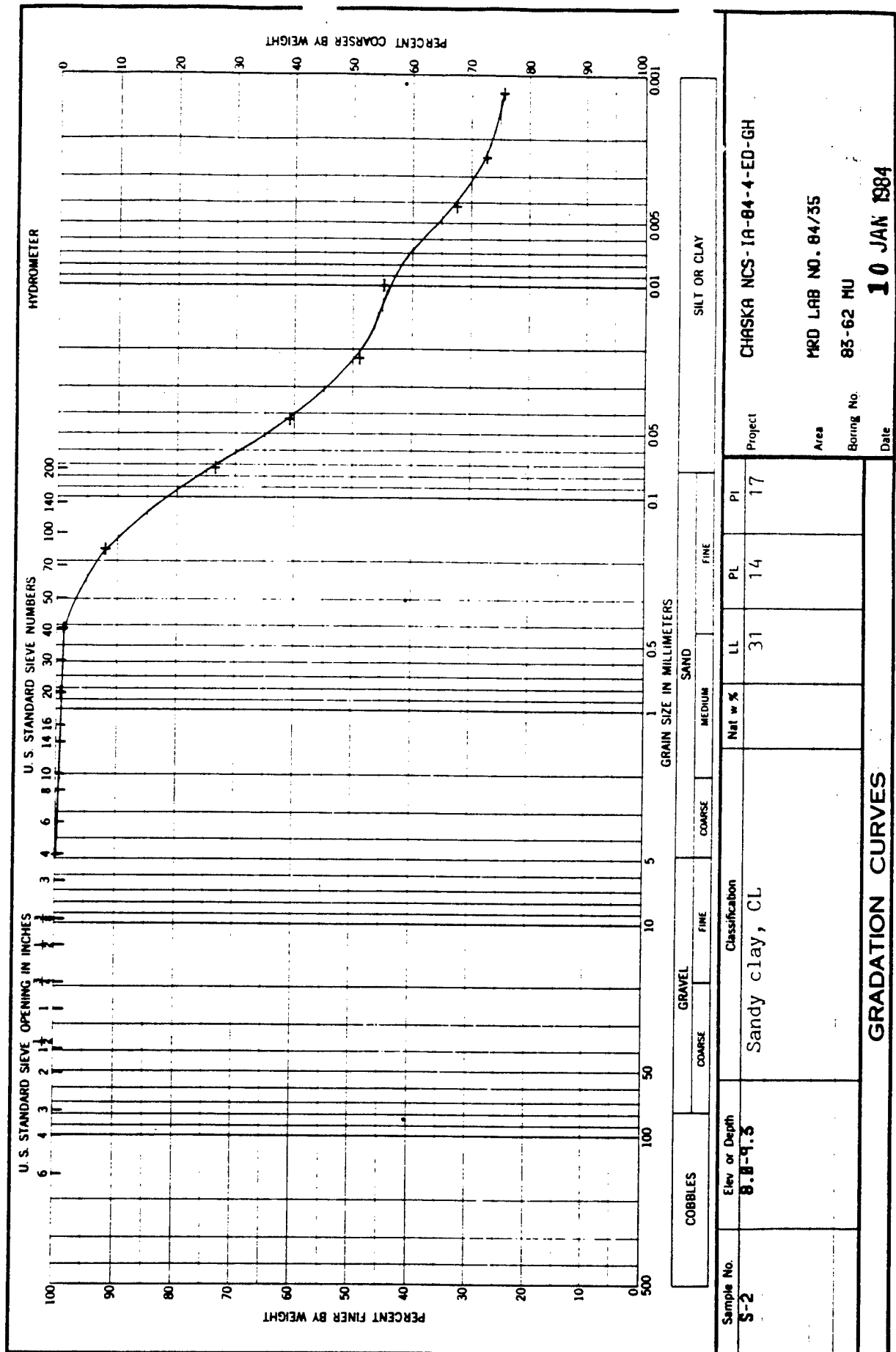
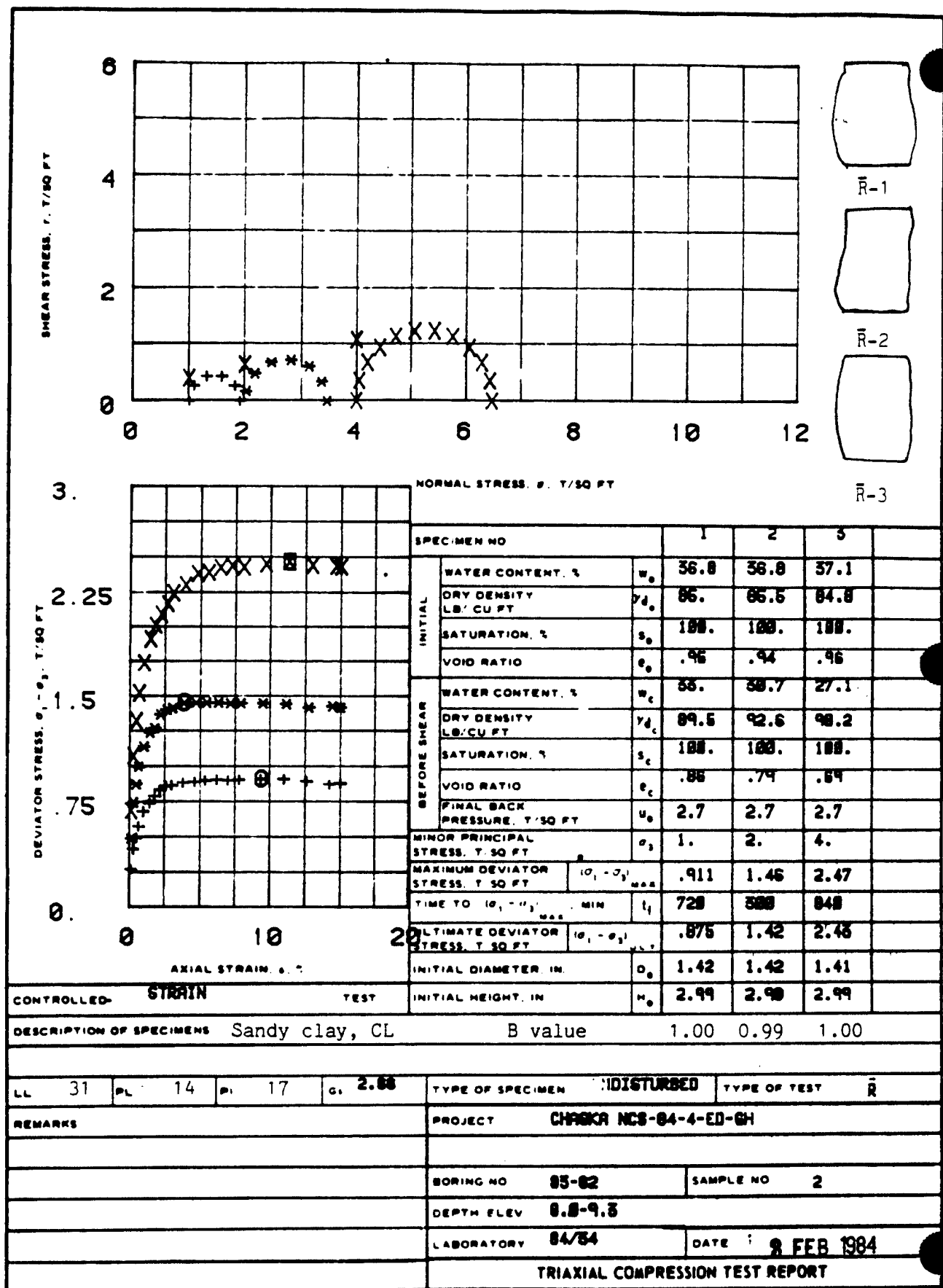


FIGURE 17

ENG FORM 2087  
1 MAY 63



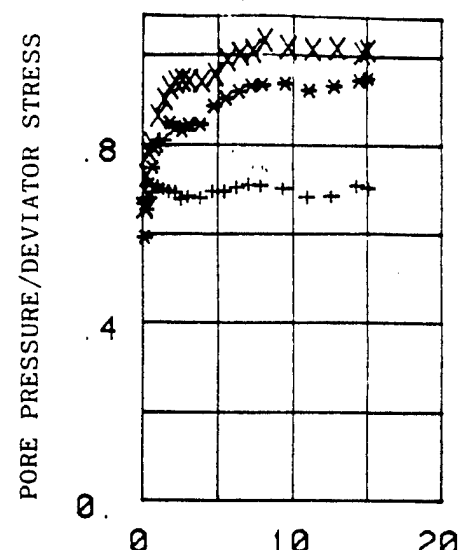
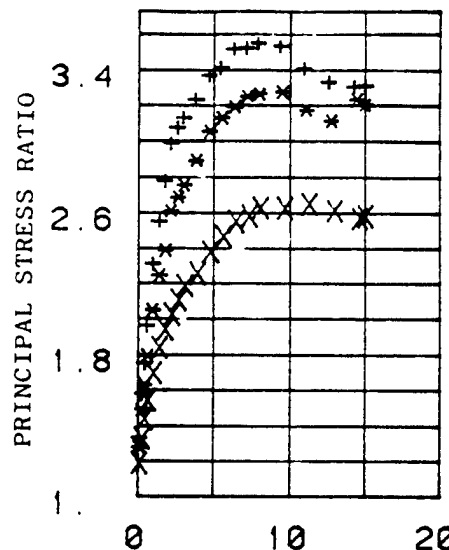
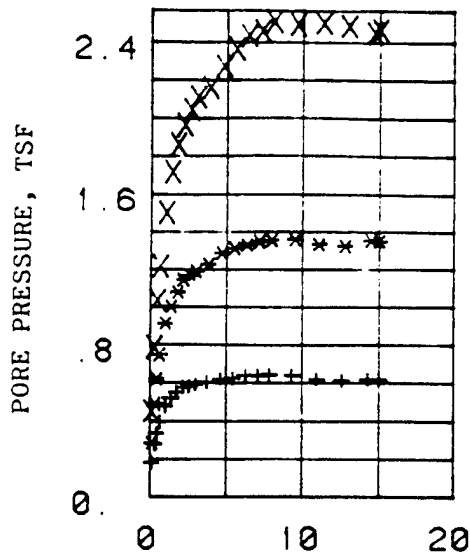
ENG FORM NO 2089  
REV JUNE 1979

PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

Figure 6

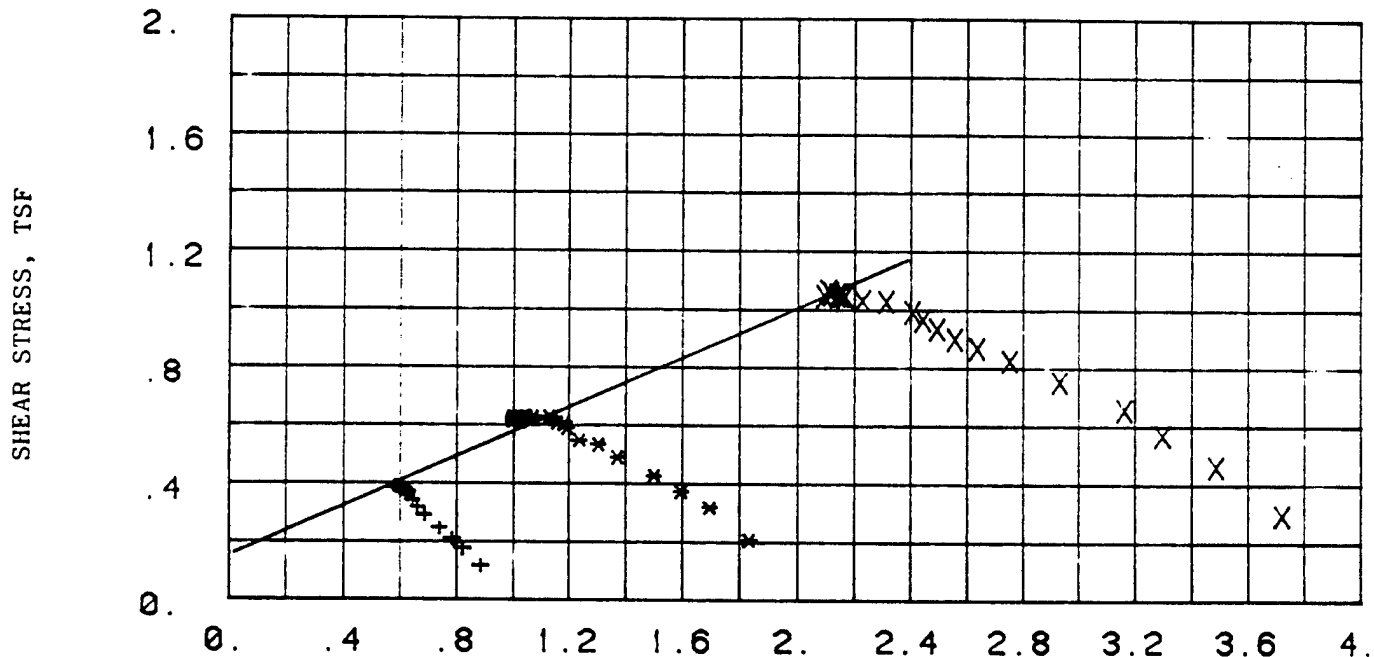


STRAIN, %

STRAIN, %

STRAIN, %

EFFECTIVE STRESS VECTOR CURVES ON 60. DEGREE PLANE

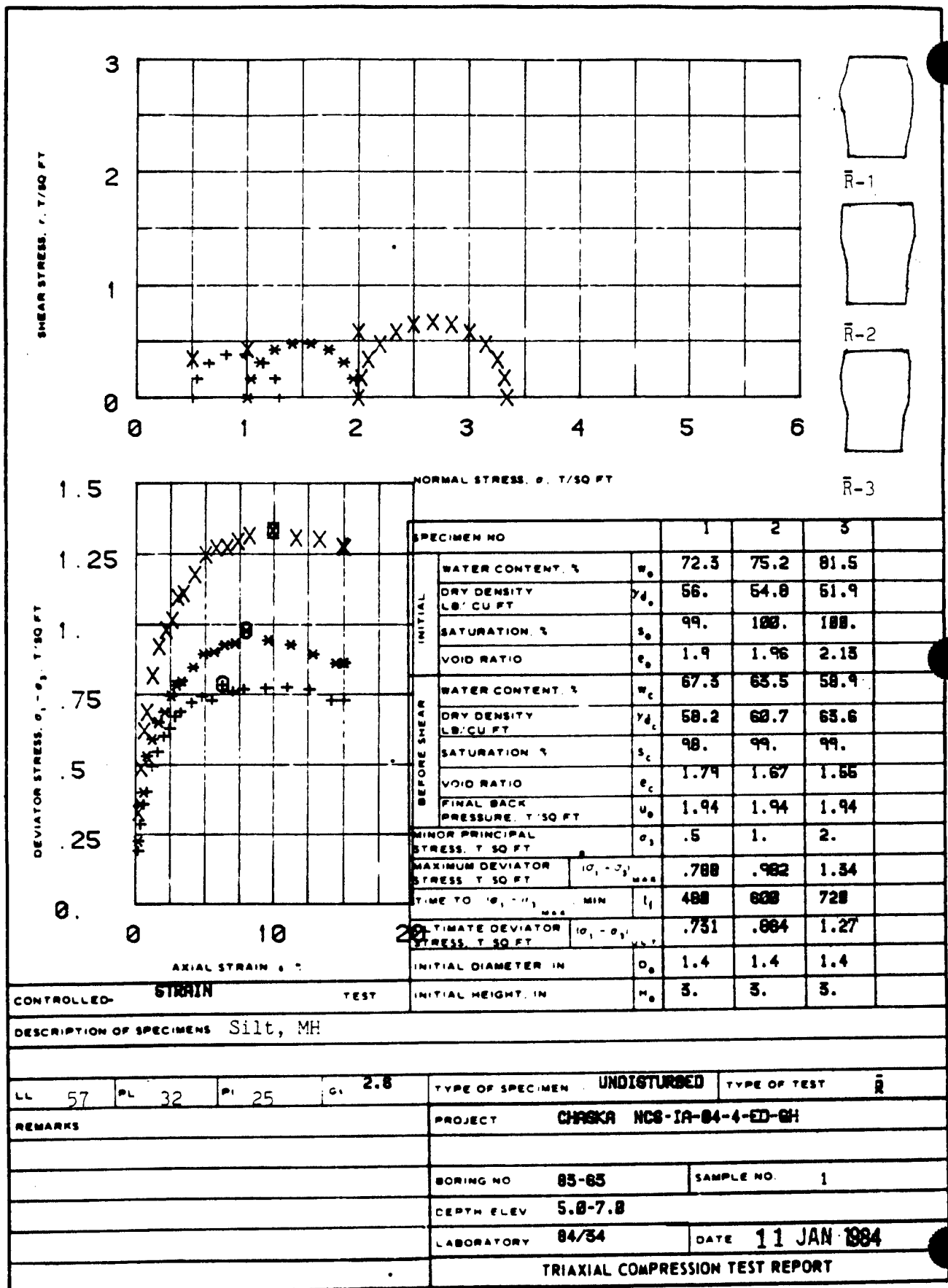


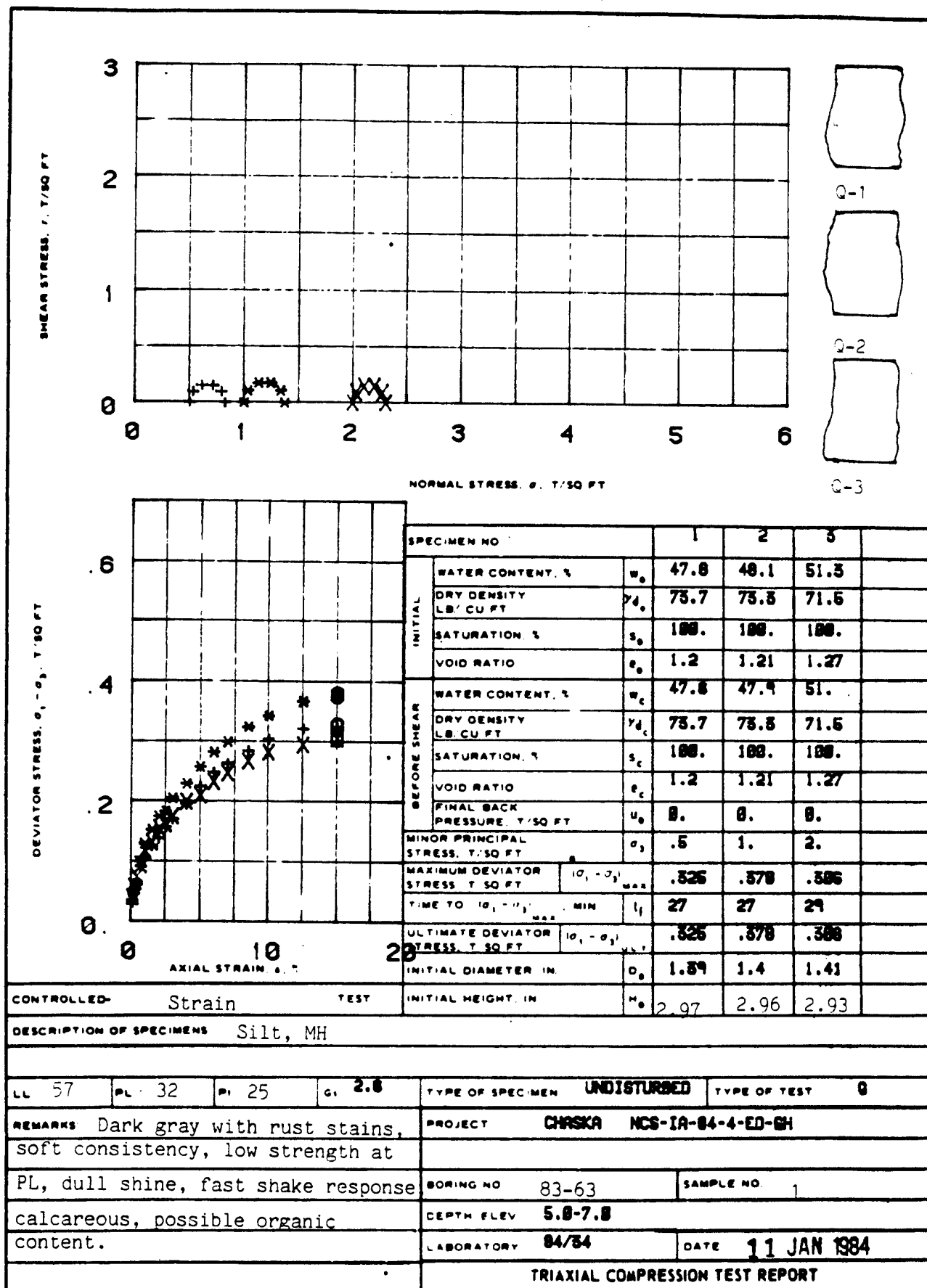
NORMAL STRESS, TSF

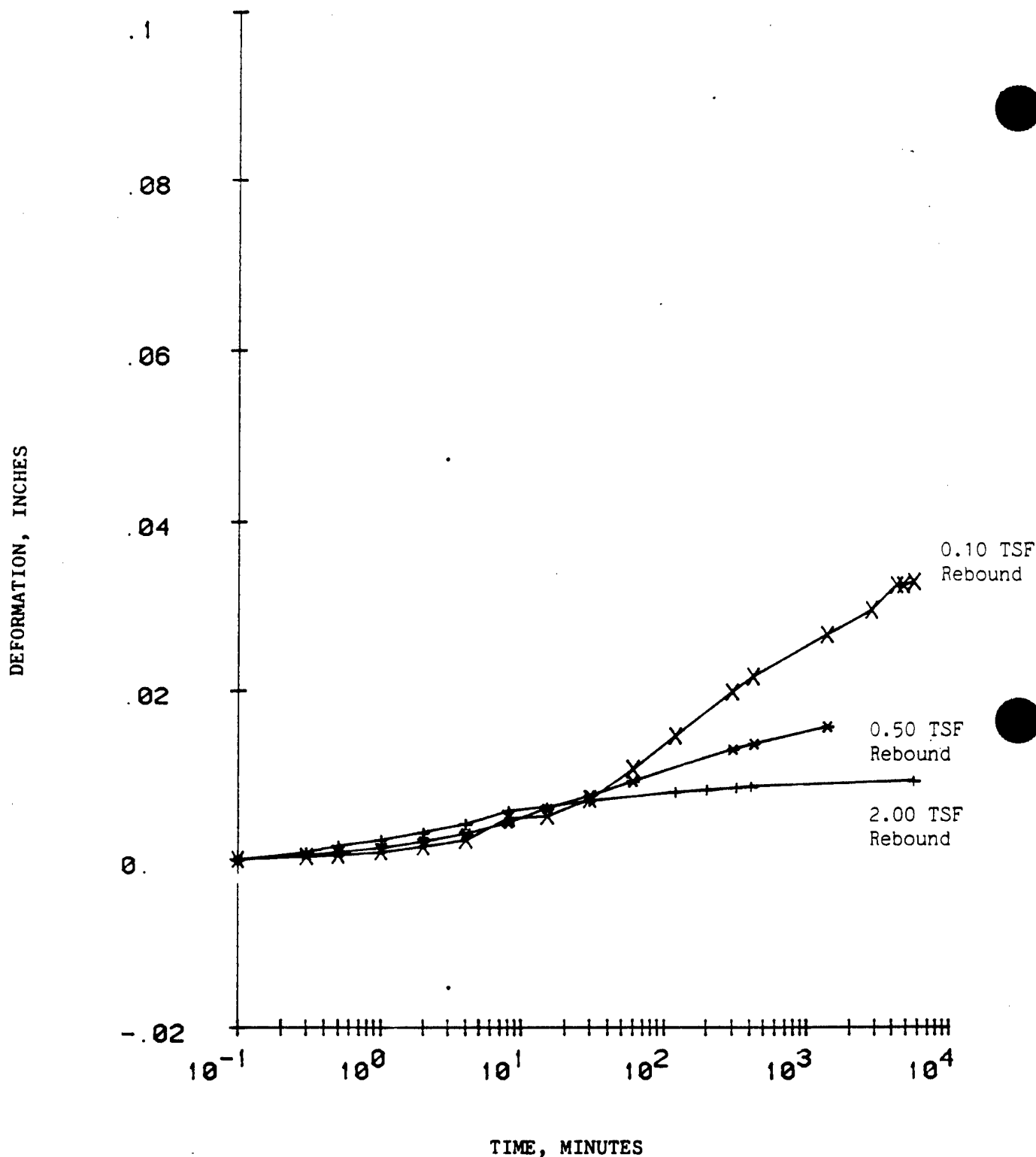
REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA NCS-84-4-ED-GH  
BORING NO: 83-62 SAMPLE NO: 2  
DEPTH/ELEV: 0.8-9.3  
MRD LAB NO: 84/34 DATE: 3 FEB 1984

TRIAXIAL COMPRESSION TEST REPORT







PROJECT: CHASKA NCS-IA-84-4-ED-GH

MRD LAB NO: 84/34

DATE: 3 FEB 1984

BORING NO: 83-63 MU SAMPLE NO: S-1

DEPTH/ELEV: 5.8-7.8

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

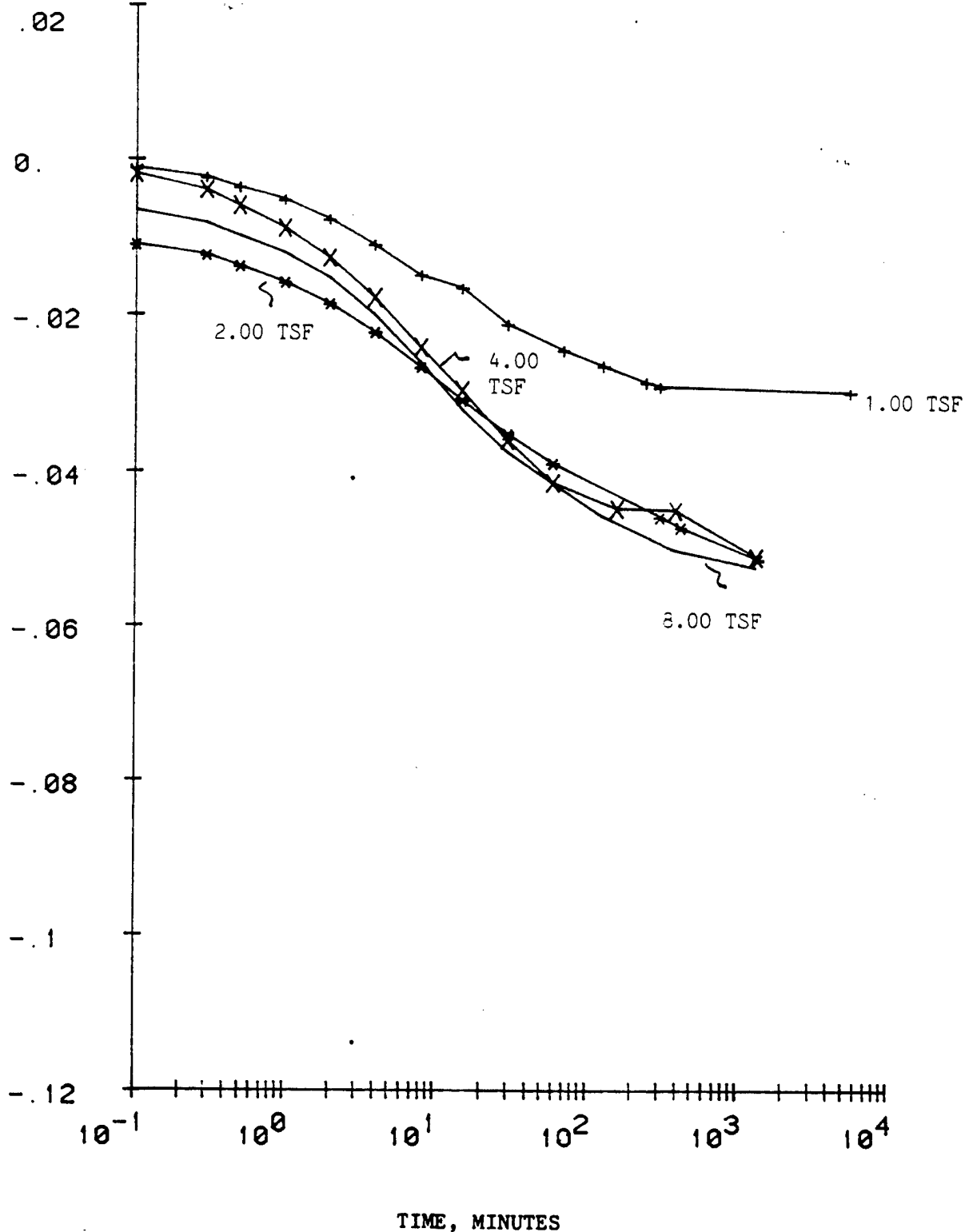
CONSOLIDATION TEST—TIME CURVES

FIGURE: 15

Figure C-148



DEFORMATION, INCHES



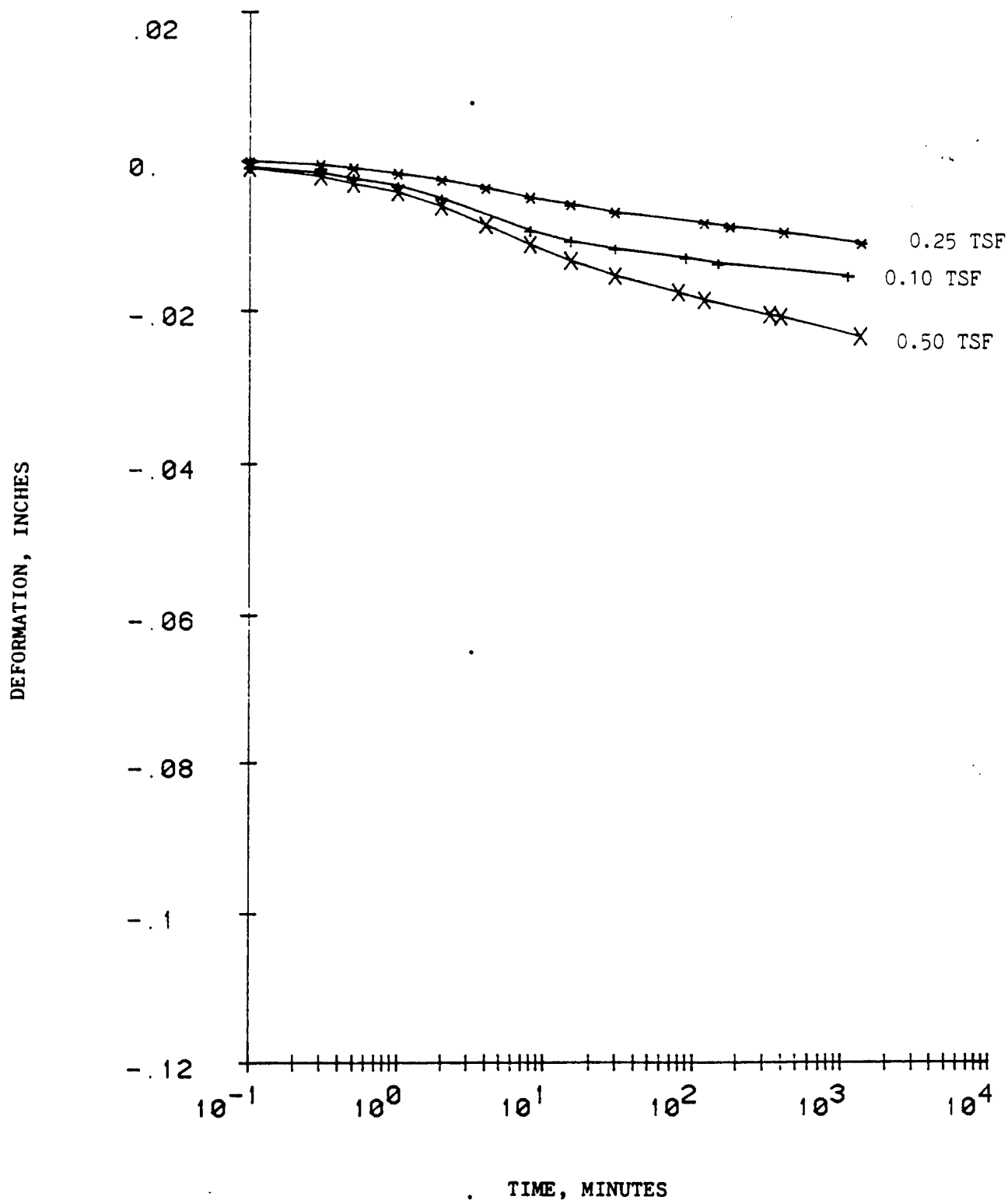
PROJECT: CHASKA NCS-IA-84-4-ED-GH  
 MRD LAB NO: 84/34  
 BORING NO: 83-63 MU SAMPLE NO: S-1

DATE: 3 FEB 1984  
 DEPTH/ELEV: 5.8-7.0

COMPUTER PRINT-OUT FORMAT  
 SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 14



PROJECT: CHASKA NCS-IA-84-4-ED-GH

MRD LAB NO: 84/34

DATE: 3 FEB 1984

BORING NO: 85-63 MU

SAMPLE NO: S-1

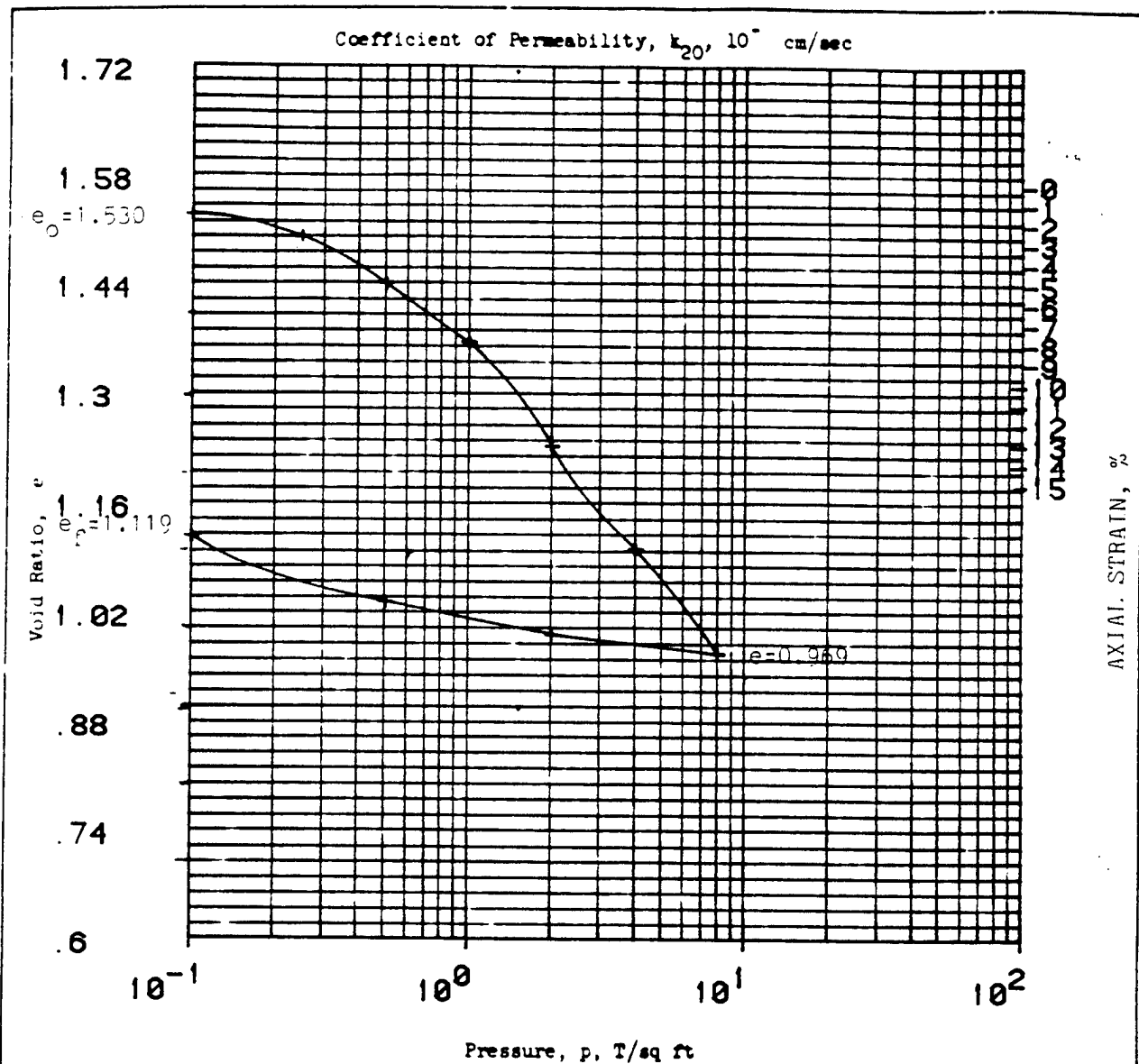
DEPTH/ELEV: 5.0-7.0

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

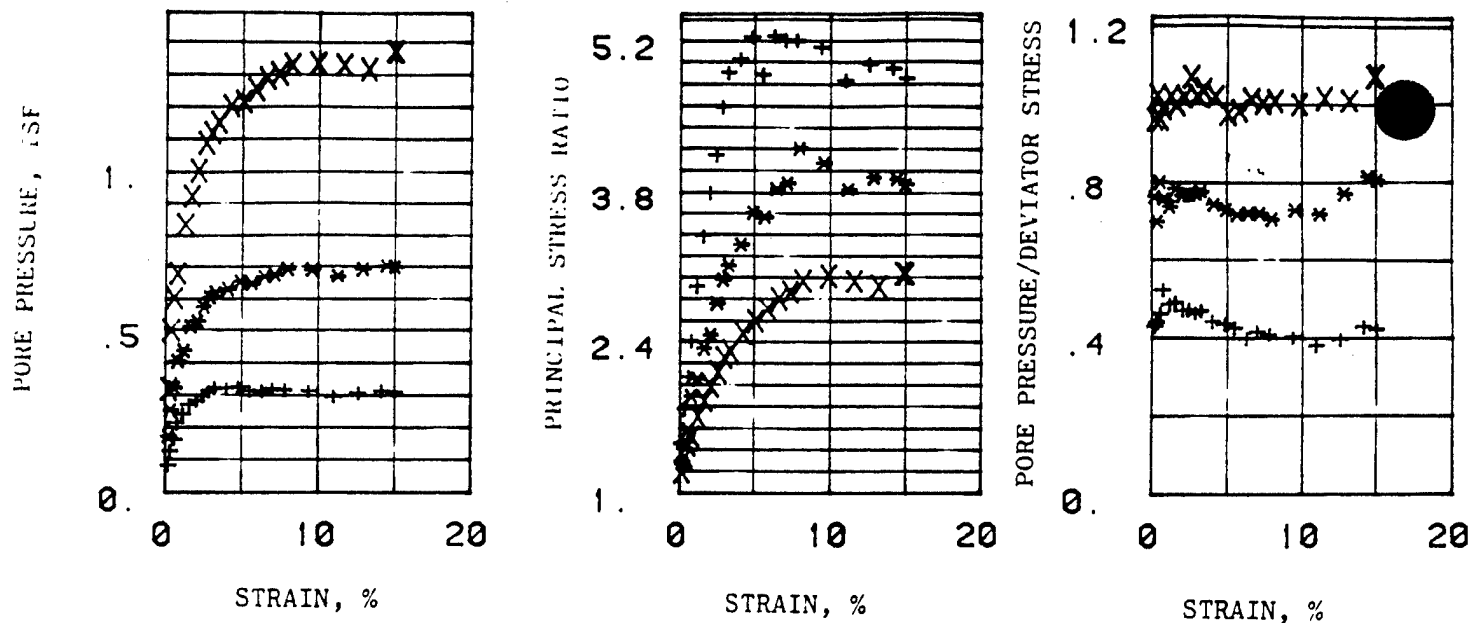
CONSOLIDATION TEST--TIME CURVES

FIGURE: 13

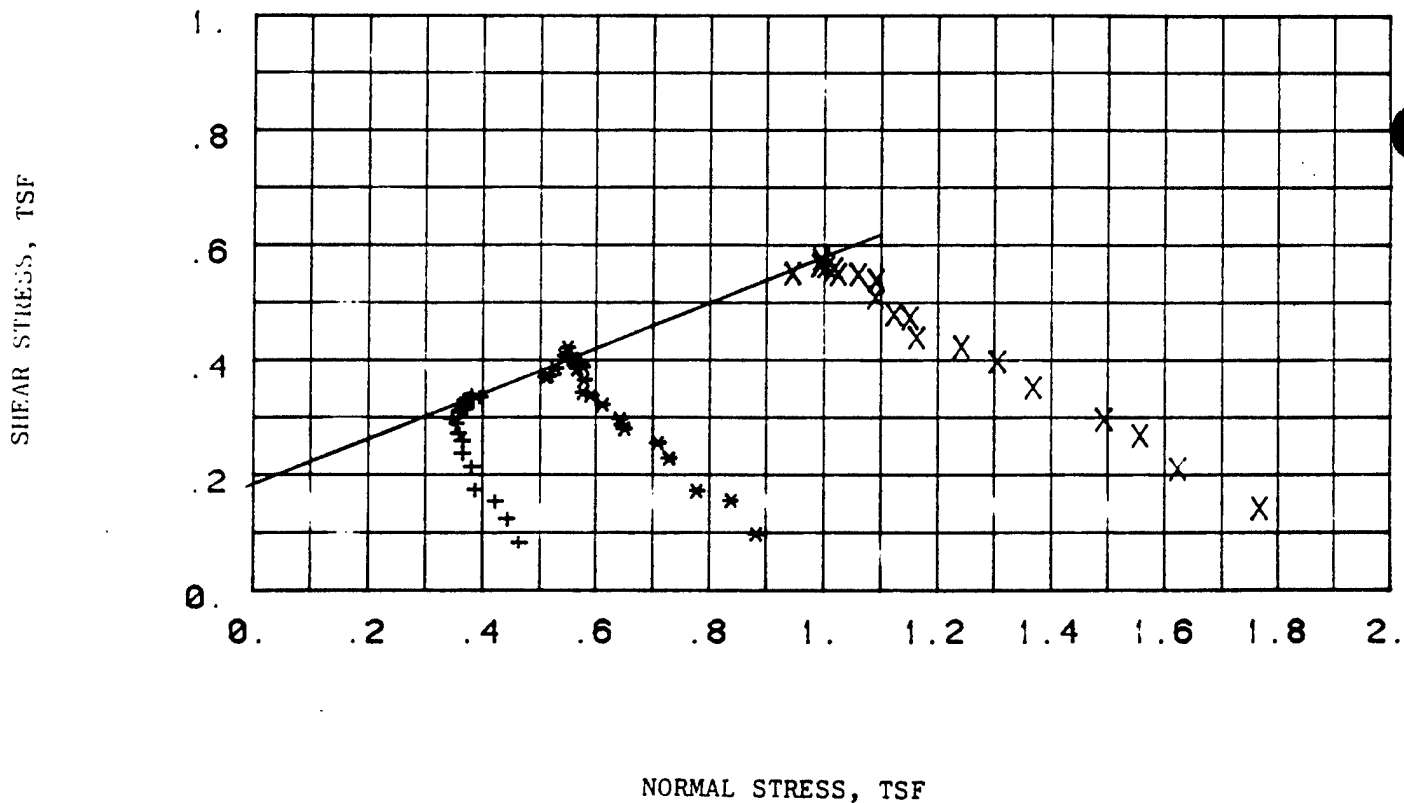
Figure C-150



Type of Specimen <b>UNDISTURBED</b>				Before Test		After Test	
Diam	4.29	in.	Ht	1.	in.	Water Content, $w_0$	59.6 %
Overburden Pressure, $p_0$				T/sq ft	Void Ratio, $e_0$	1.57	$e_f$ 1.12
Preconsol. Pressure, $p_c$				T/sq ft	Saturation, $S_0$	99. %	$S_f$ 95. %
Compression Index, $C_c$				Dry Density, $\gamma_d$		63.1	lb/ft <sup>3</sup>
Classification Silt, MH				$k_{20}$ at $e_0$ = $\times 10^{-7}$ cm/sec			
LL	57	$G_s$	2.6	Project <b>CHASKA</b> NCS-IA-84-4-ED-GH			
PL	32	$D_{10}$					
Remarks				Area <b>MRO LAB NO: 84/34</b>			
				Boring No. <b>83-63 MU</b>		Sample No. <b>S-1</b>	
				Depth <b>5.8-7.8</b>		Date <b>3 FEB 1984</b>	
				<b>CONSOLIDATION TEST REPORT</b>			



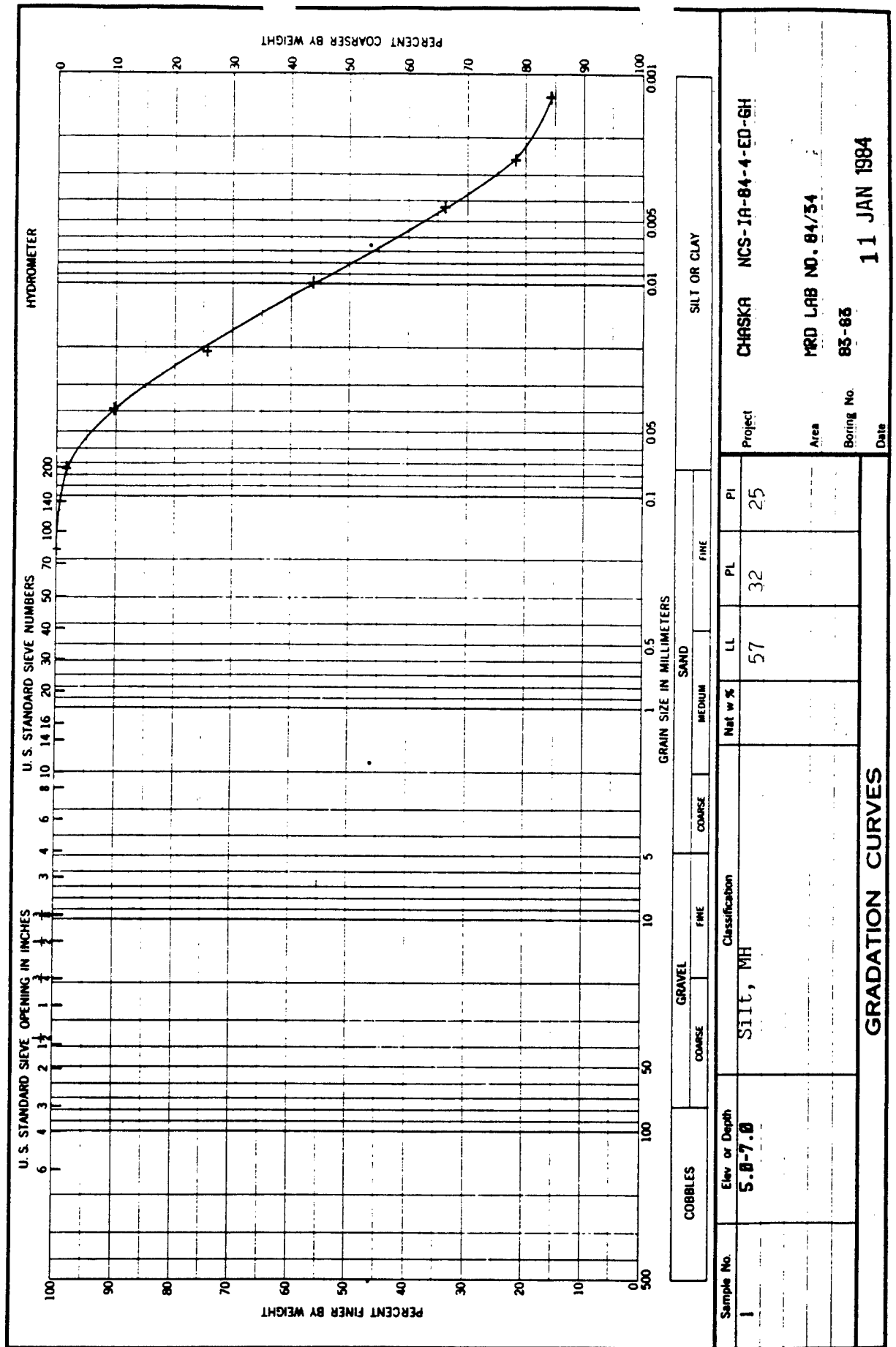
EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



REMARKS: COMPUTER PRINT-OUT  
SYMBOLS SAME AS FORM 2089  
R TRIAXIAL TEST: PORE PRESSURE  
MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-84-4-ED-6H  
BORING NO: 83-05 SAMPLE NO: 1  
DEPTH/ELEV: 5.8-7.8  
MRD LAB NO: 84/34 DATE: 11 JAN 1984

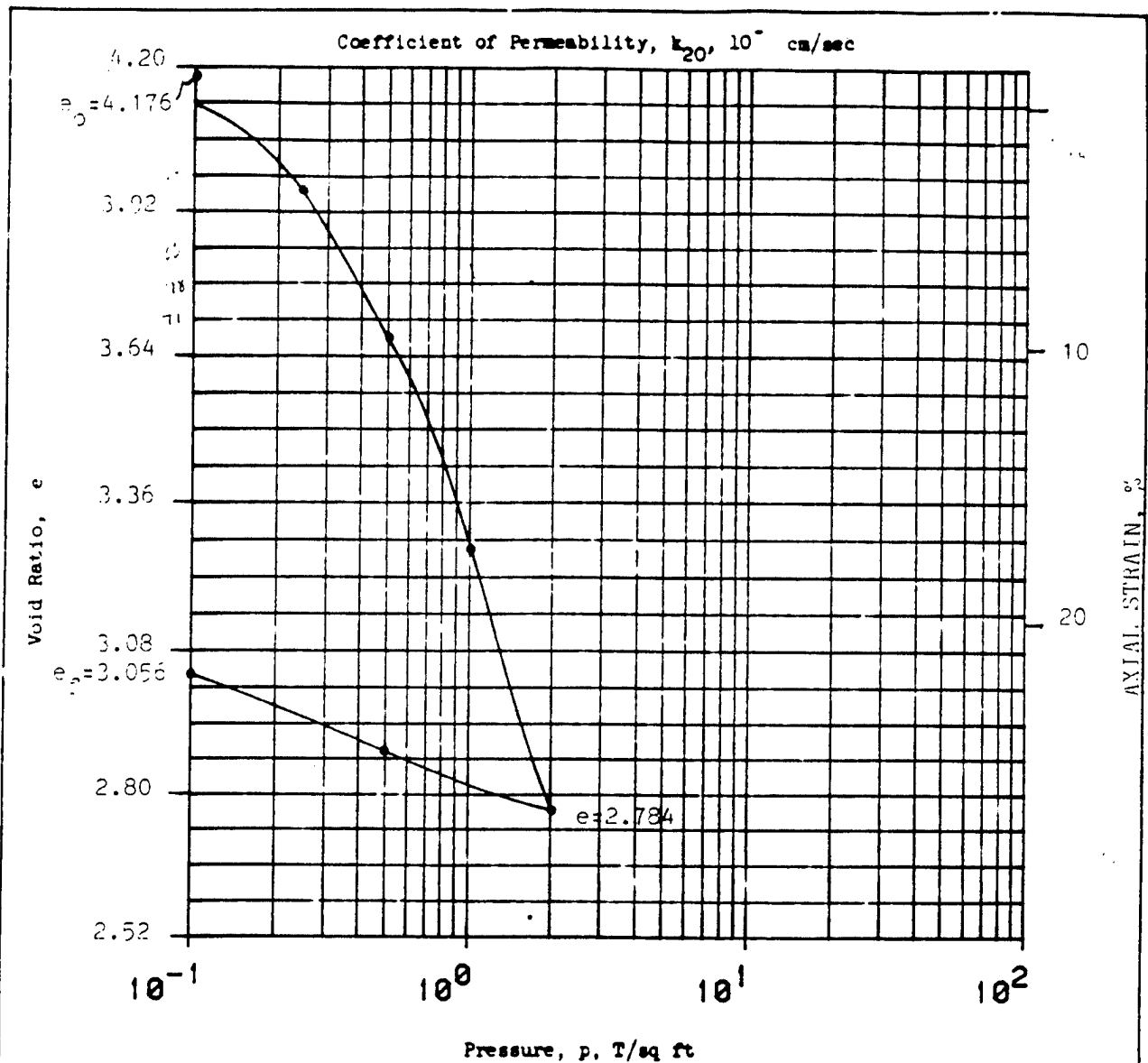
TRIAXIAL COMPRESSION TEST REPORT



Sample No.	1	Elev or Depth	5.8-7.0	Classification	Silt, MH	LL	57	PL	32	PI	25
Project				CHASKA NCS-1A-84-4-ED-6H		Area		MRD LAB NO. 84/34		Boring No. 83-83	
Date				11 JAN 1984		Date		11 JAN 1984		Date	

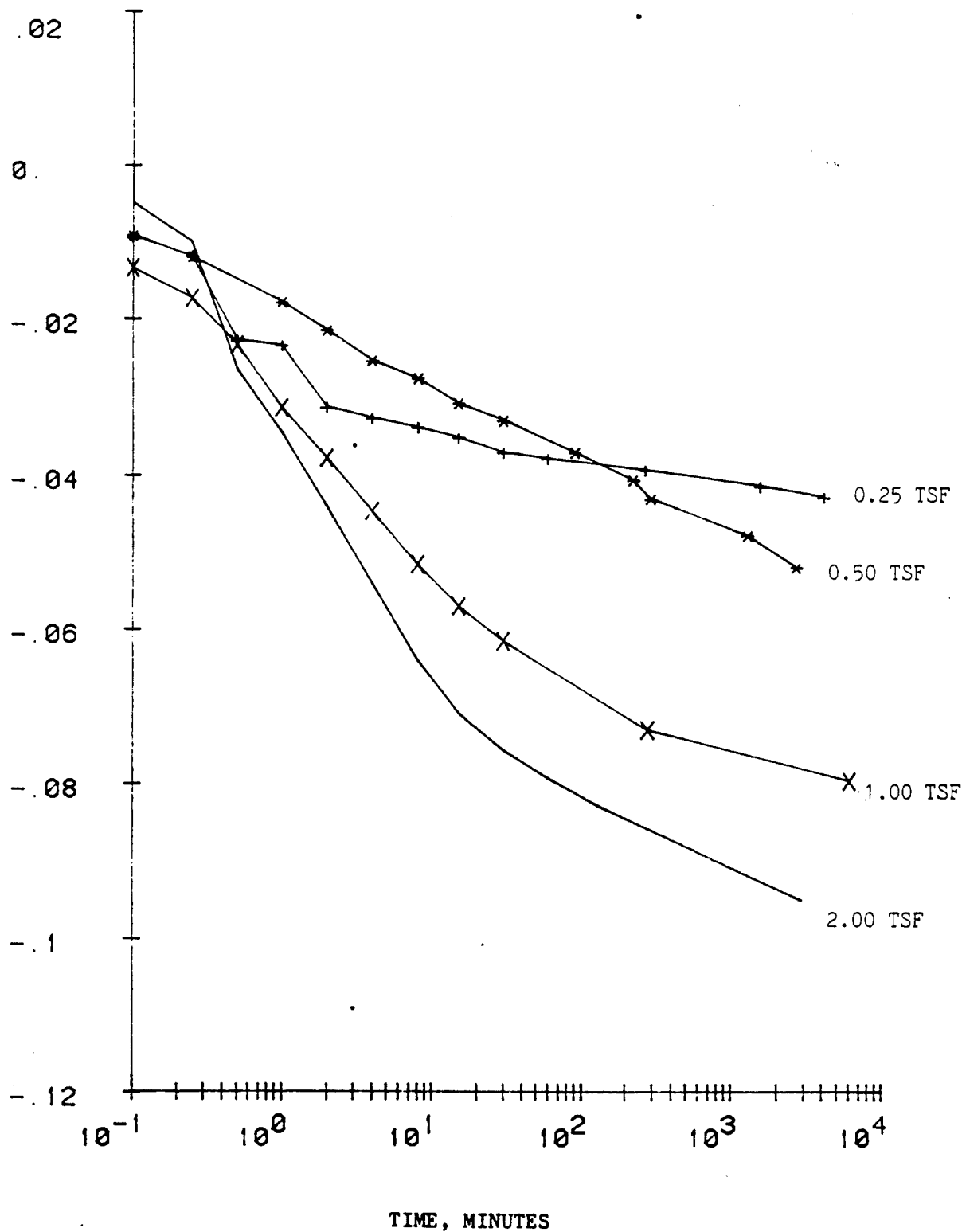
**GRADATION CURVES**

Figure C-153



Type of Specimen <b>UNDISTURBED</b>				Before Test		After Test	
Diam <b>4.29</b> in.	Ht <b>1.</b> in.	Water Content, $w_0$	<b>181.</b> %	$w_f$	<b>136.</b> %		
Overburden Pressure, $p_0$ T/sq ft		Void Ratio, $e_0$	<b>4.10</b>	$e_f$	<b>3.06</b>		
Preconsol. Pressure, $p_c$ T/sq ft		Saturation, $S_0$	<b>98.</b> %	$S_f$	<b>100.</b> %		
Compression Index, $C_c$		Dry Density, $\gamma_d$	<b>27.1</b> lb/ft <sup>3</sup>				
Classification Organic, OH		$k_{20}$ at $e_0$ = $\times 10^{-7}$ cm/sec					
LL <b>182</b>	$G_s$ <b>2.25</b>	Project <b>CHASKA NCS-IA-84-4-ED-GH</b>					
PL <b>93</b>	$D_{10}$						
Remarks The change in height exceeded travel in test apparatus so the specimen was rebounded from 2.0 TSF.		Area <b>MRD LAB NO: 84/34</b>					
		Boring No. <b>83-63 MU</b>			Sample No. <b>S-2</b>		
		Depth <b>13.8-15.8</b>			Date <b>3 FEB 1984</b>		
		<b>CONSOLIDATION TEST REPORT</b>					

DEFORMATION, INCHES



PROJECT: CHASKA NCS-1A-84-4-ED-6H

MRD LAB NO: 84/34

DATE: 3 FEB 1984

BORING NO: 83-63 MU

SAMPLE NO: S-2

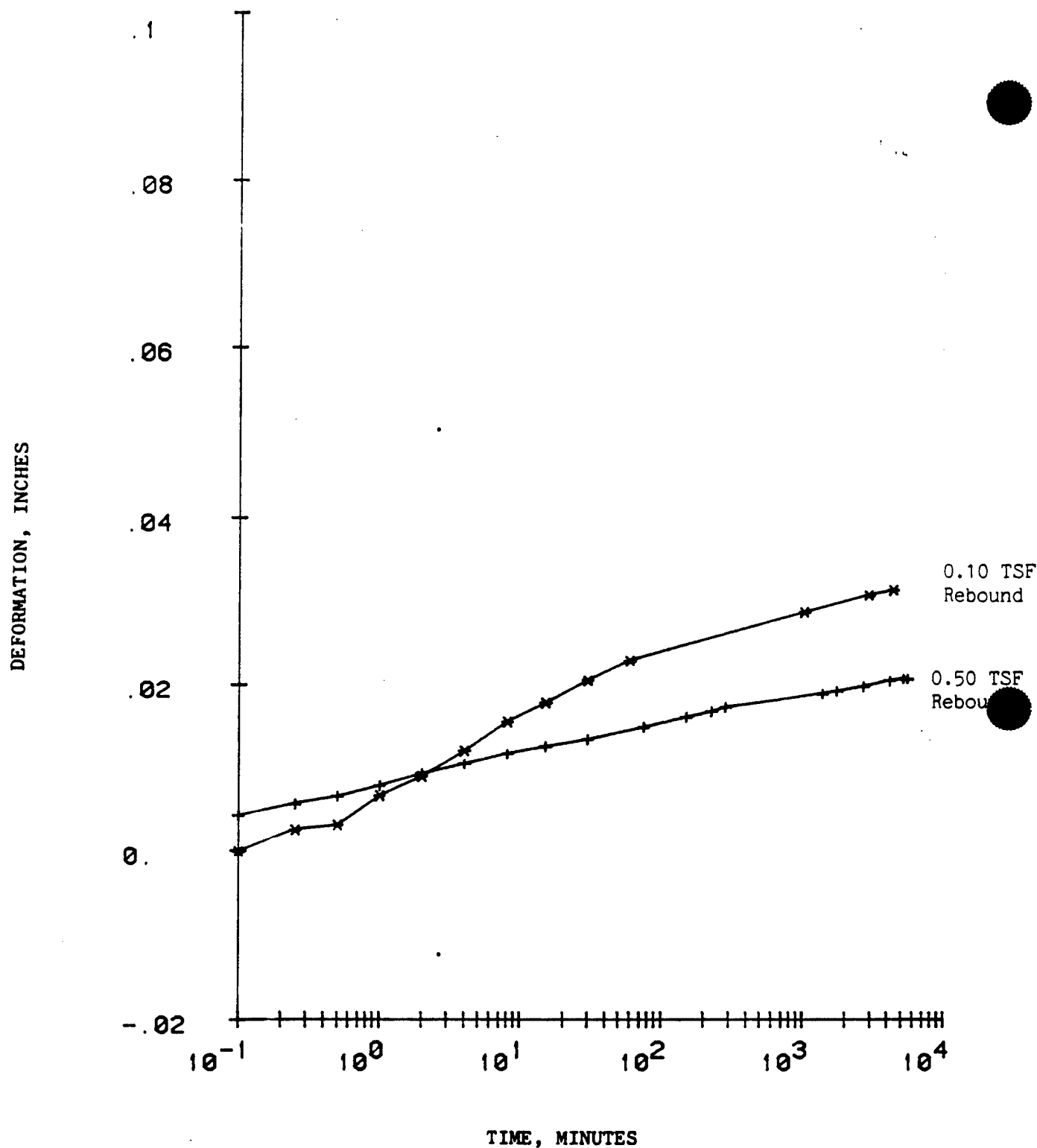
DEPTH/ELEV: 13.0-15.0

COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 19

Figure C-155



PROJECT: CHASKA NCS-1A-84-4-ED-GH

MRD LAB NO: 84/34

DATE: 3 FEB 1984

BORING NO: 85-63 MU

SAMPLE NO: S-2

DEPTH/ELEV: 13.0-15.0

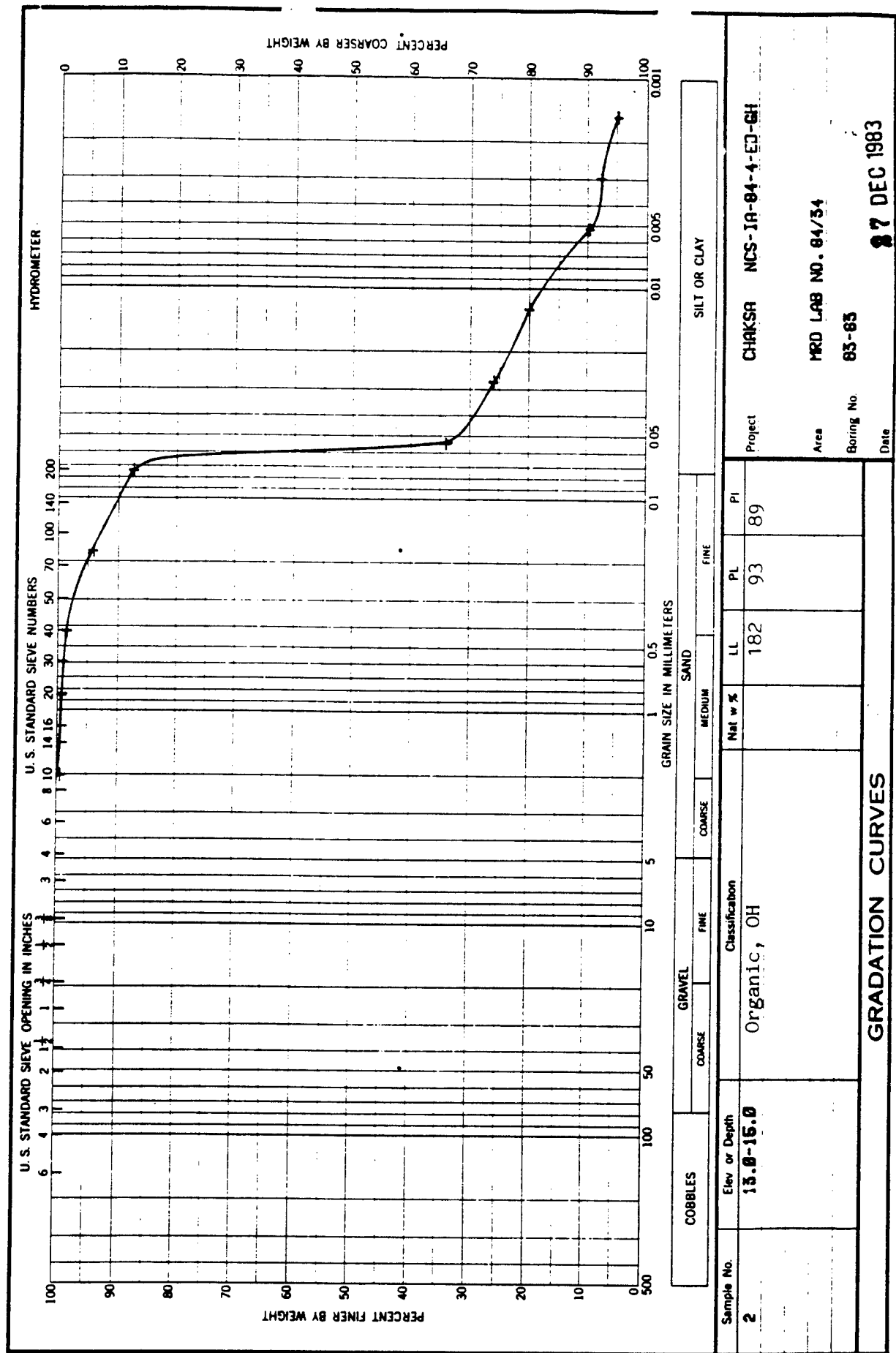
COMPUTER PRINT-OUT FORMAT  
SAME AS ENG FORM 2088

CONSOLIDATION TEST—TIME CURVES

FIGURE: 20

Figure C-156





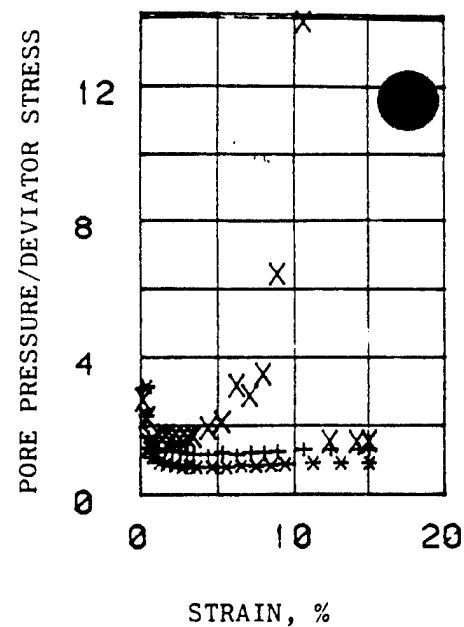
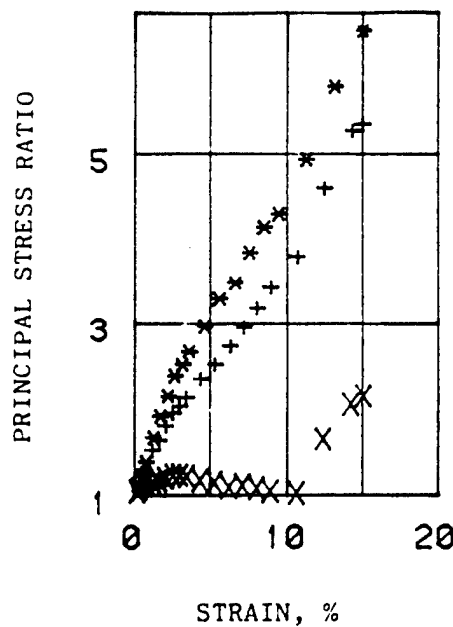
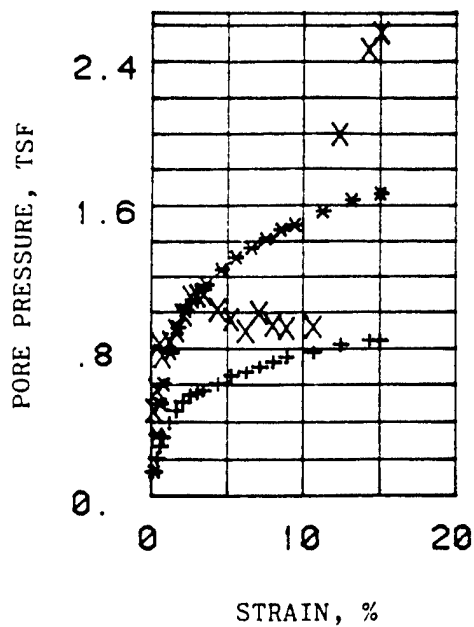
ENG FORM 2087  
1 MAY 83

Figure C-157

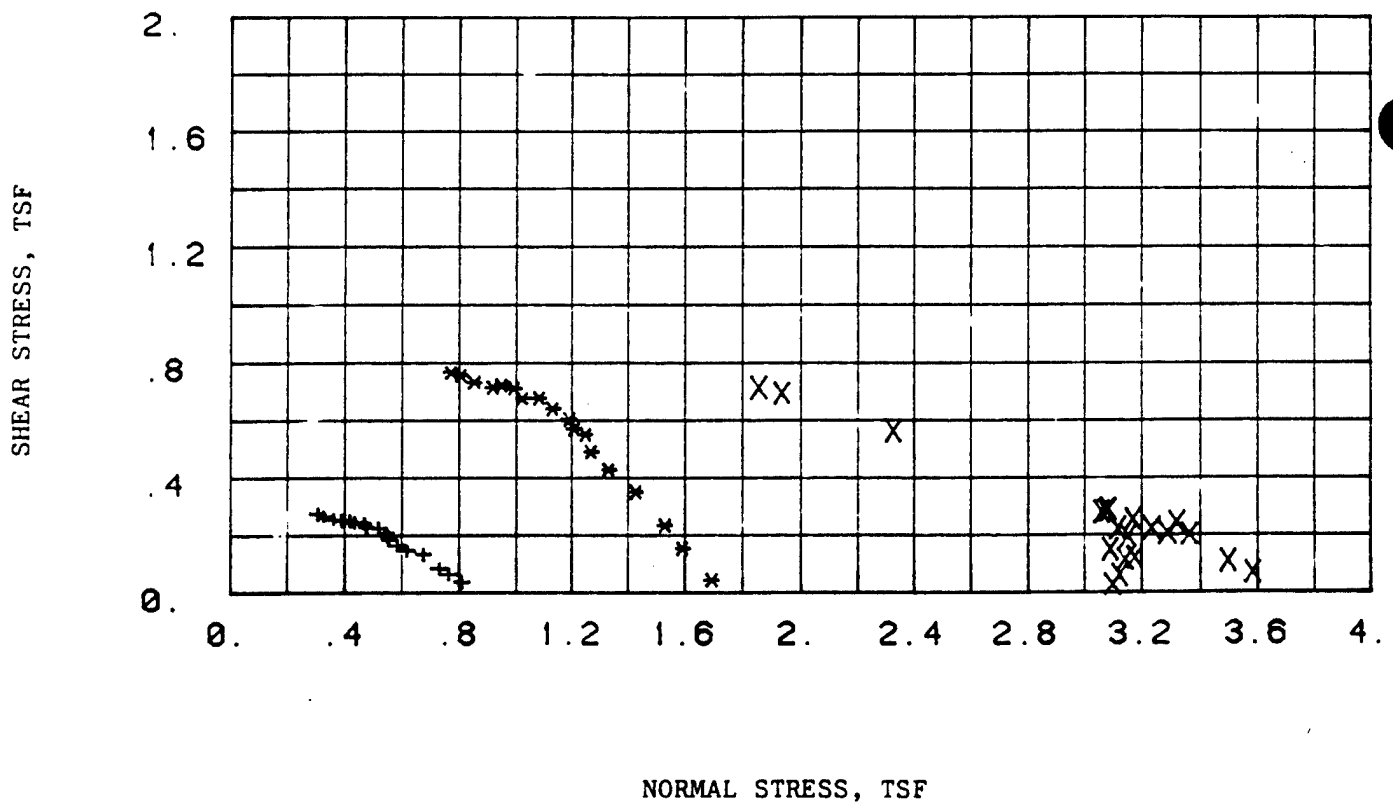
Figure 30

Figure C-158





EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



REMARKS: COMPUTER PRINT-OUT  
 SYMBOLS SAME AS FORM 2089  
 TRIAXIAL TEST: PORE PRESSURE  
 MONITORED DURING SHEAR

PROJECT: CHASKA NCS-1A-84-4-ED-GH  
 BORING NO: 85-85N SAMPLE NO: 2  
 DEPTH/ELEV: 13-15  
 MRD LAB NO: 84/34 DATE: 8 FEB 1984

TRIAXIAL COMPRESSION TEST REPORT

# TRIAXIAL TEST DATA

Date March 3, 1988

Job No. 4220 88-226

Project Chaska Creek Diversion

Boring No. 87-72M

Sample No. 1

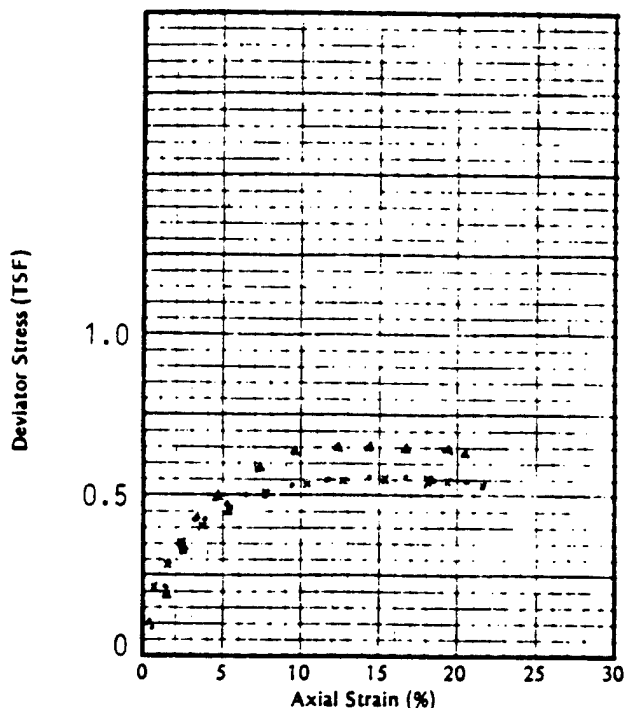
Depth (ft) 4-6

Type of Sample 5T

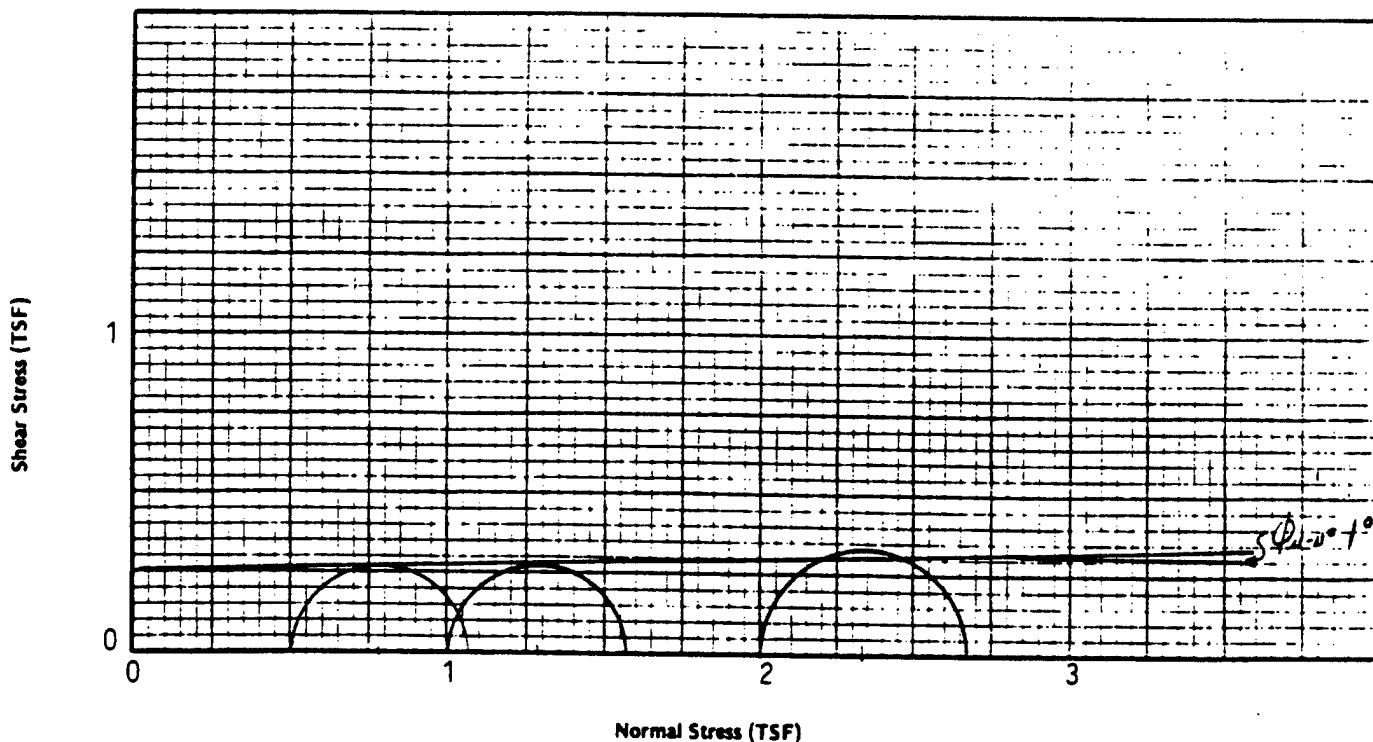
Soil Type Organic Clay (OH)

Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage valves closed; stressed to given strains at constant rate of 0.060"/min.; Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.97	1.97	1.98	
	Height (inches)	3.87	3.87	4.15	
	Moisture Content (%)	49.6	50.6	50.3	
	Dry Density (PCF)	71.1	70.2	70.3	
	Saturation (%)	100	100	100	
	Void Ratio	1.28	1.31	1.30	
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF $(\sigma_3)$		0.50	1.00	2.00	
Maximum Deviator Stress TSF $(\sigma_1 - \sigma_3)$		0.56	0.55	0.66	
Ultimate Deviator Stress TSF $(\sigma_1 - \sigma_3)$					
LL	77.5	PI	39.1		
PL	38.4	G <sub>s</sub>	2.60		



# TRIAXIAL TEST DATA

Date April 1, 1988

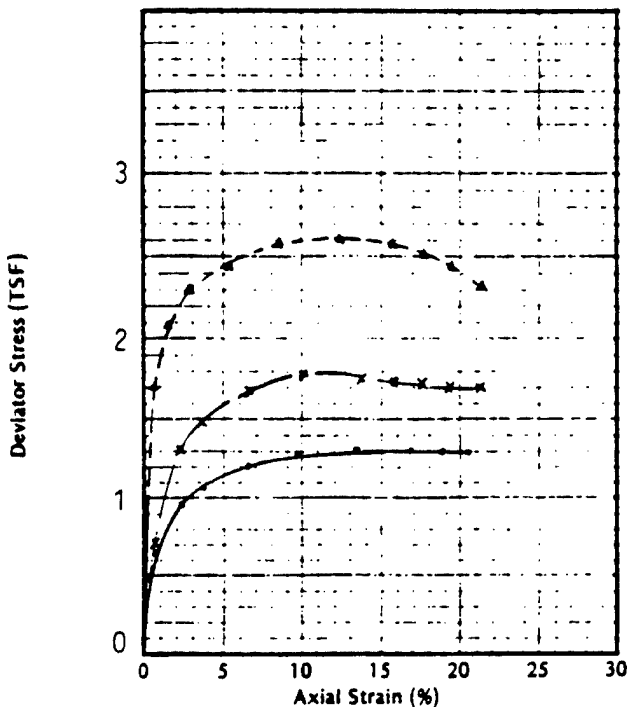
Job No. 4220 88-226

Project Chaska Creek Diversion

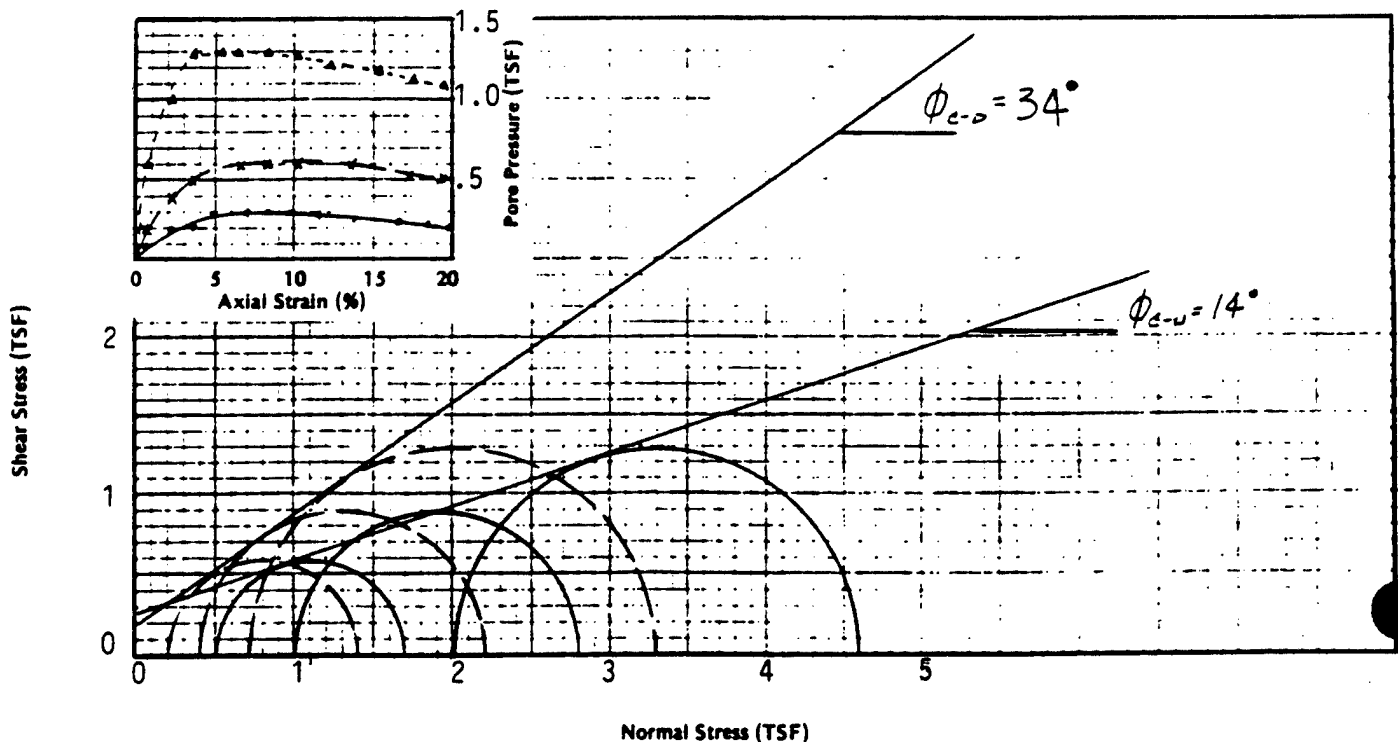
Boring No. 87-72M Sample No. 1 Depth (ft) 4-6 Type of Sample 5T

Soil Type Organic Clay (OH) Type of Test C-U W/Pore Pressure

Remarks: Specimens trimmed to given sizes; radial (spiral) drainage strips applied;  
saturated for 6 days under low confinement; backpressure and effective confining  
pressures increased in stages, to values shown; then maintained for 17-22 days;  
stressed under constant strain rates of 0.006"/min; Mohr circles at maximum stress ratio.



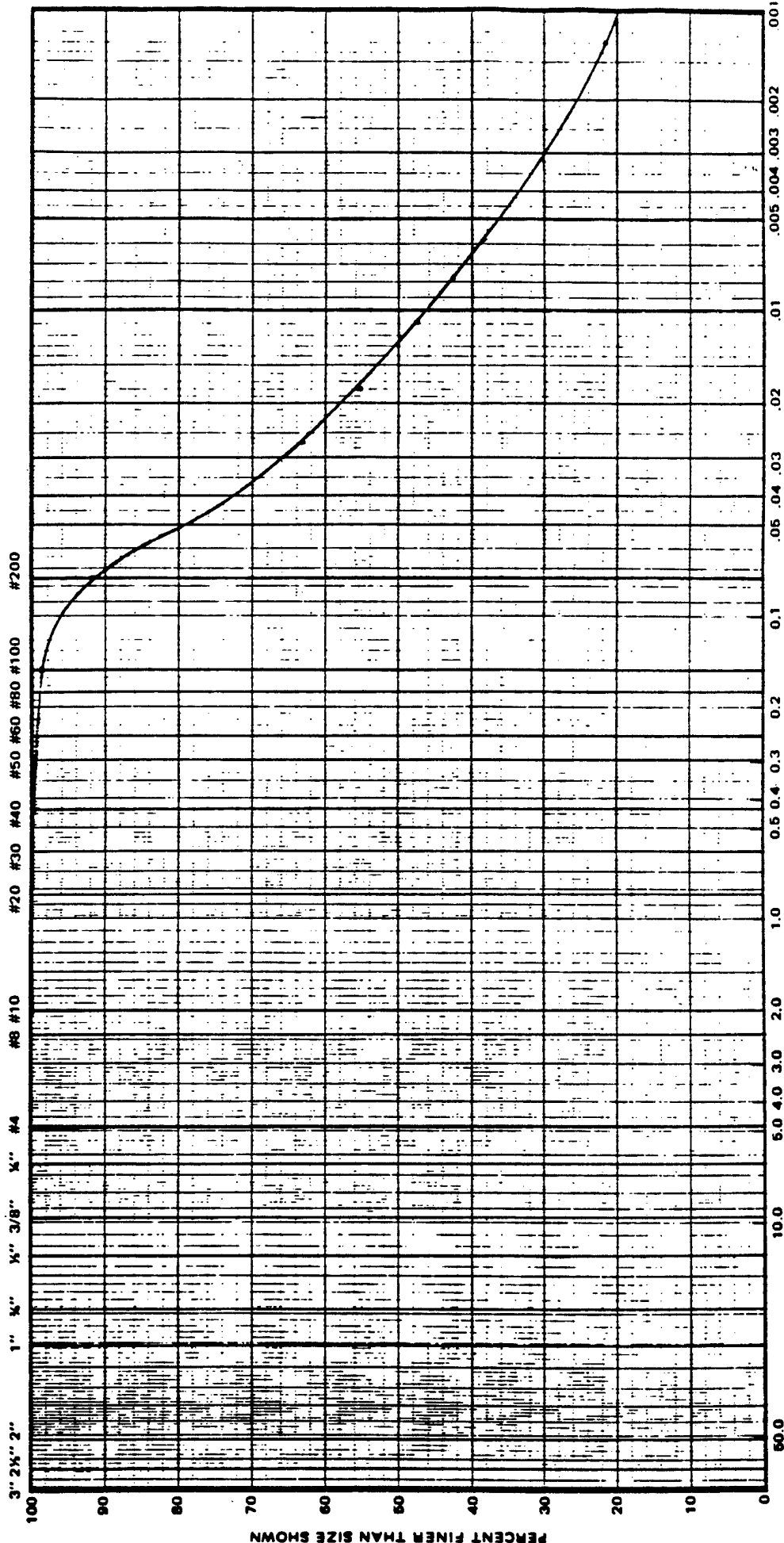
SPECIMEN NO.		1A	1B	1C	
Initial	Diameter (inches)	1.40	1.40	1.40	
	Height (inches)	2.90	2.88	2.86	
	Moisture Content (%)	56.4	55.5	54.5	
	Dry Density (PCF)	65.3	65.8	66.4	
	Saturation (%)	98.7	98.5	98.1	
	Void Ratio	1.48	1.47	1.44	
Before Shear	Moisture Content (%)	48.6	44.9	40.7	
	Dry Density (PCF)	71.8	74.9	78.3	
	Saturation (%)	100	100	100	
	Void Ratio	1.26	1.17	1.07	
	Back Pressure (TSF)	6.12	6.12	6.12	
Minor Principal Stress TSF $\sigma_3$		0.50	1.00	2.00	
Maximum Deviator Stress TSF $\sigma_1 - \sigma_3$		1.24	1.77	2.61	
Ultimate Deviator Stress TSF $\sigma_1 - \sigma_3$		1.2	1.7	2.3	
LL	77.5	PI	39.1		
PL	38.5	G <sub>s</sub>	2.60		



# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE March 8, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-72M SAMPLE NO. 1 DEPTH (FT) 4-6 SOIL TYPE Organic Clay (OH)

U.S. STANDARD SIEVE SIZES



GRAVEL			SAND			FINES	
COARSE	FINE		COARSE	MEDIUM	FINE		

# TRIAXIAL TEST DATA

Date March 3, 1988

Job No. 4220 88-226

Project Chaska Creek Diversion

Boring No. 87-72M

Sample No. 2

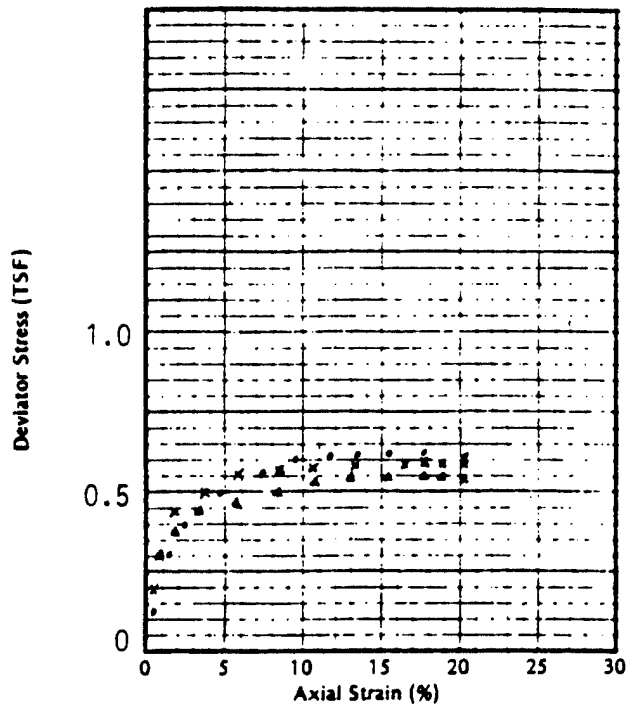
Depth (ft) 10-12

Type of Sample 5T

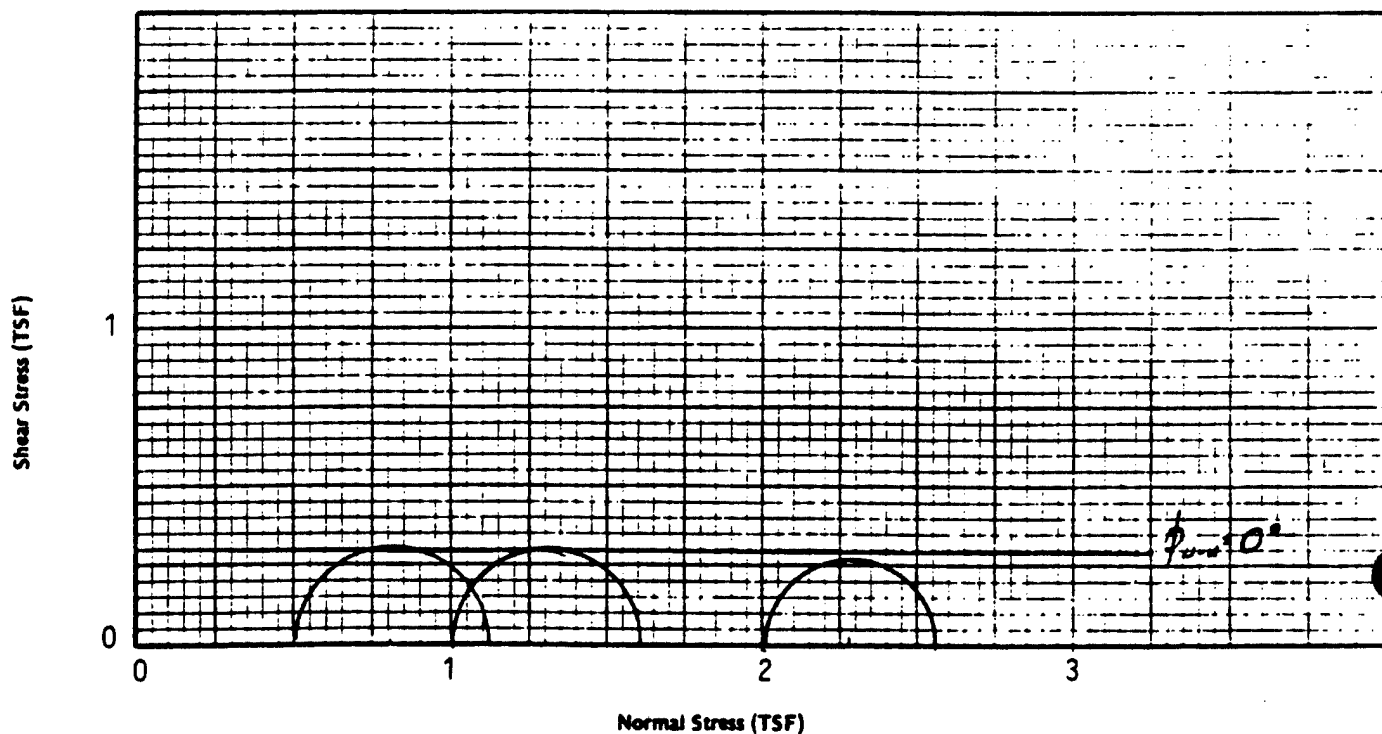
Soil Type Fat Clay (CH)

Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage valves closed; stressed to given strains at constant rate of 0.060"/min.; Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.99	1.99	2.00	
	Height (inches)	4.22	4.22	4.23	
	Moisture Content (%)	44.8	39.2	42.2	
	Dry Density (PCF)	77.4	80.2	77.1	
	Saturation (%)	100	95.4	95.7	
	Void Ratio	1.19	1.12	1.20	
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF ( $\sigma_3$ )		0.50	1.00	2.00	
Maximum Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		0.62	0.60	0.55	
Ultimate Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )					
LL 63.5	PI 42.1				
PL 21.4	G <sub>s</sub> 2.72				





# TRIAXIAL TEST DATA

Date June 13, 1988

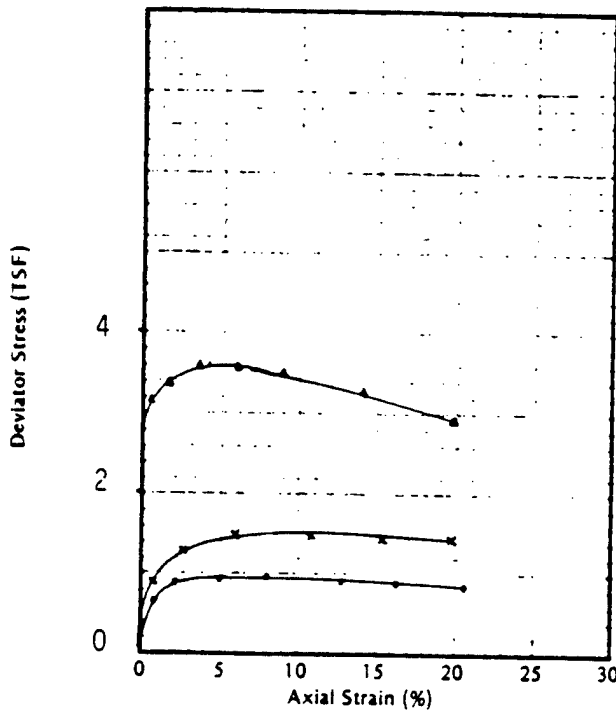
Job No. 4220 88-226

Project Chaska Creek Division

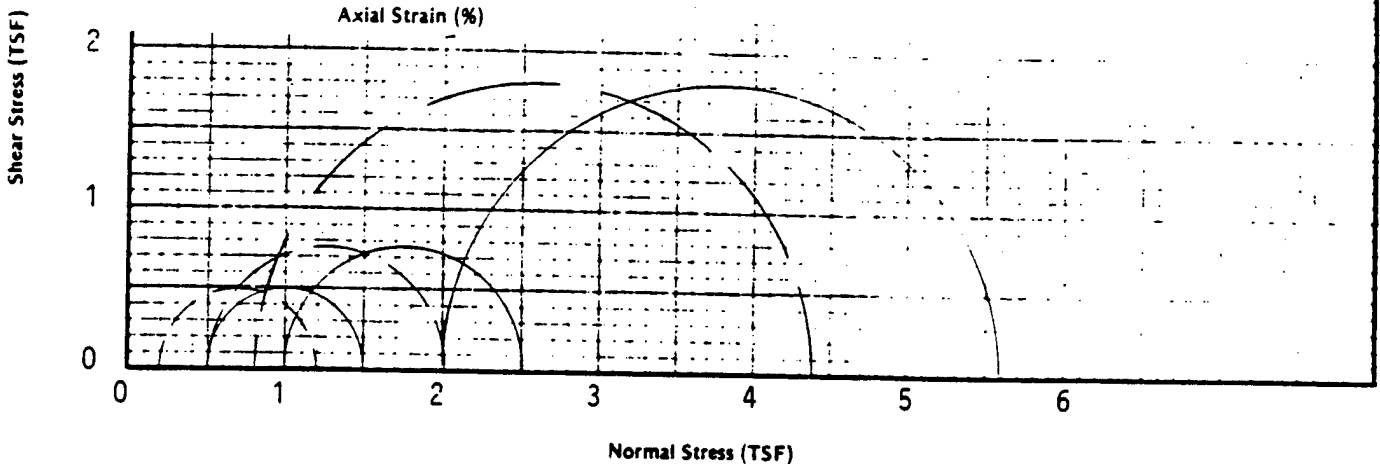
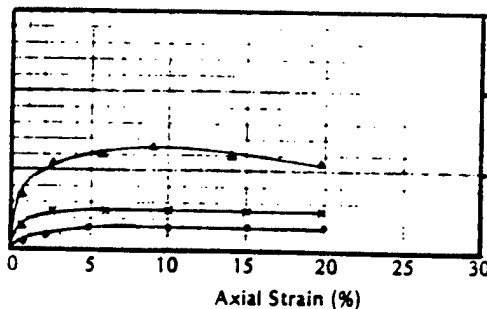
Boring No. 87-72m Sample No. 2 Depth (ft) 10-12 Type of Sample 5" Core

Soil Type Fat Clay (CH) Type of Test C-U w/pp

Remarks: Specimens trimmed to given sizes; radial (spiral) drainage strips applied; saturated for 18-28 days under low confinement; back pressure and effective confining pressures increased in stages, to values shown; then maintained for 14-15 days; stressed under constant strain rates of 0.006"/min; mohr circles at maximum stress ratio.

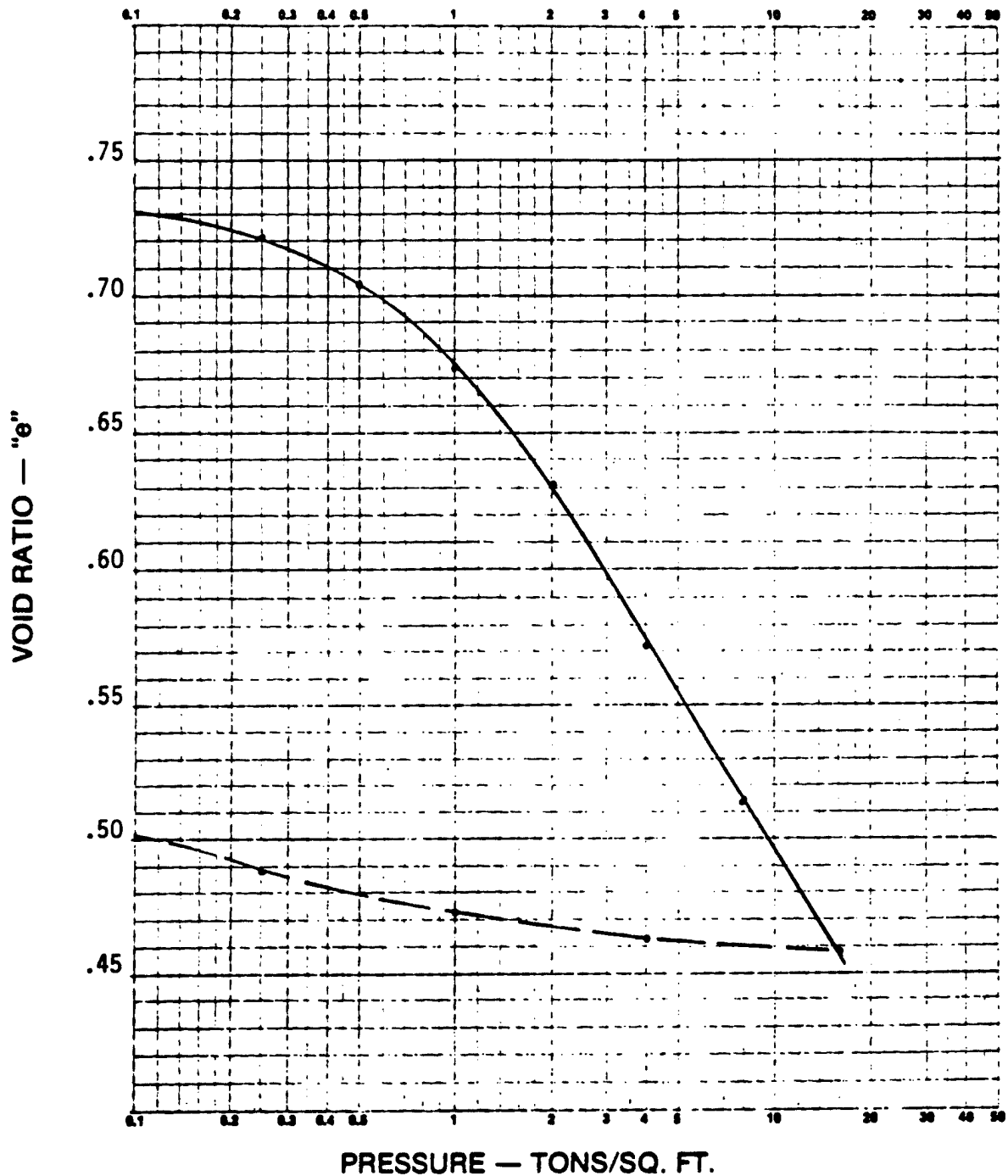


SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.41	1.41	1.42	
	Height (inches)	2.94	3.04	3.08	
	Moisture Content (%)	28.3	28.3	20.8	
	Dry Density (PCF)	86.4	89.3	94.0	
	Saturation (%)	79.9	85.5	70.1	
	Void Ratio	.96	.90	.81	
Before Shear	Moisture Content (%)	34.5	31.2	26.7	
	Dry Density (PCF)	87.5	91.7	98.2	
	Saturation (%)	99.8	99.6	99.7	
	Void Ratio	.94	.85	.73	
	Back Pressure (TSF)	6.12	6.12	6.12	
Minor Principal Stress TSF ( $\sigma_3$ )		0.50	1.00	2.00	
Maximum Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		0.98	1.51	3.60	
Ultimate Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		0.8	1.4	2.9	
LL 63.5	PI 42.1				
PL 21.4	G <sub>s</sub> 2.72				



# CONSOLIDATION TEST CURVE

VOID RATIO VS. PRESSURE



Project CHASKA CREEK DIVERSION

Job No. 87-72M

GS = 2.72

Date May 2, 1988

Boring No. 87-72M

Soil Type (ASTM: D2487) Fat clay (CH)

Sample No. 2

Original Moisture Content, Dry Density 27.7 % 96.4 PCF

Depth (FT.) 10-12

Liquid Limit 63.5 % Plastic Limit 21.4 %

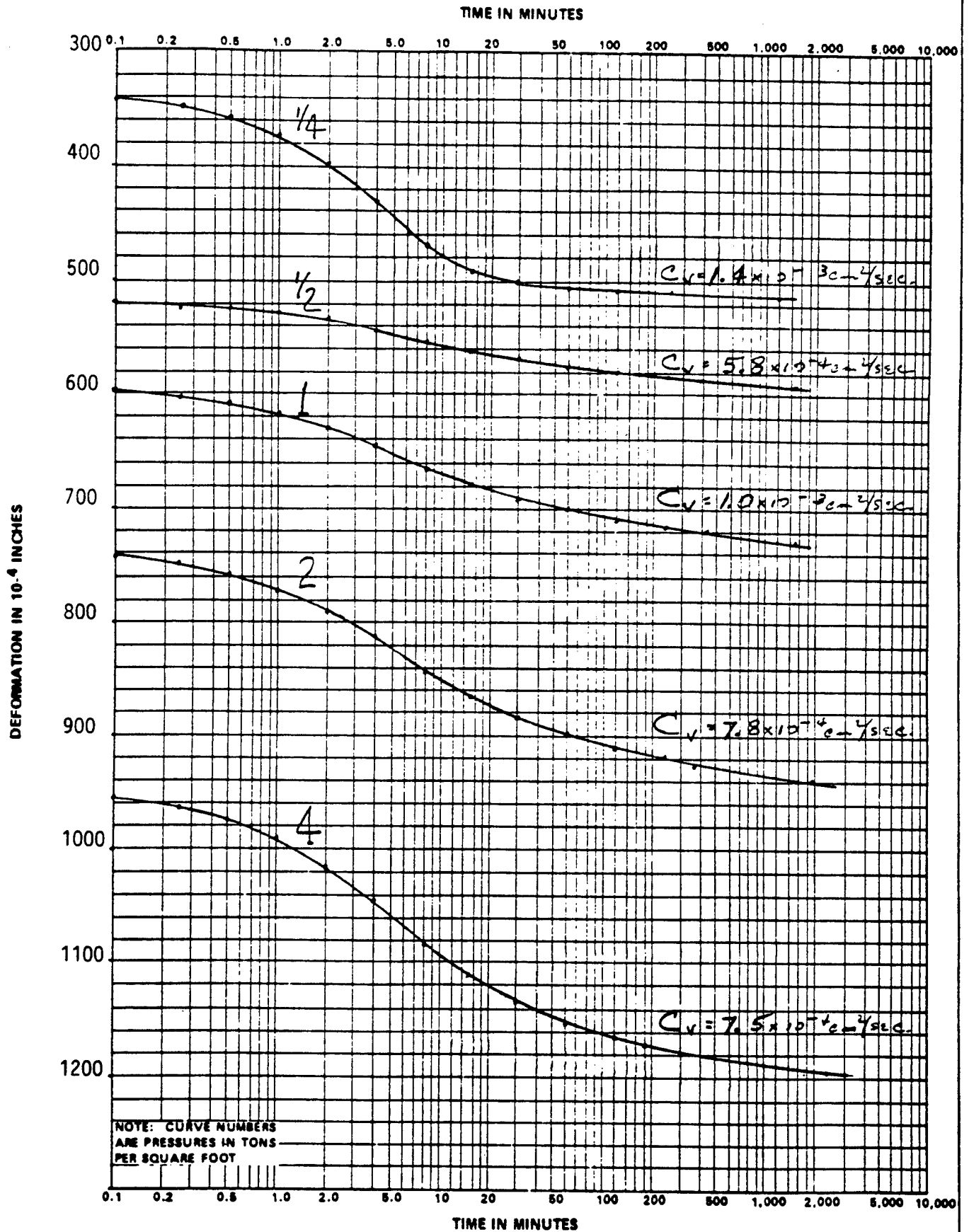
Initial Sample Height (IN.) 0.795

Preconsolidation Pressure (Pc) 0.9 TSF

Sample Diameter (IN.) 2.501

Compression & Recompression Index: C<sub>c</sub> 0.19 C<sub>r</sub> 0.04

# CONSOLIDATION TEST TIME CURVES



PROJECT: CHASKA CREEK DIVERSION

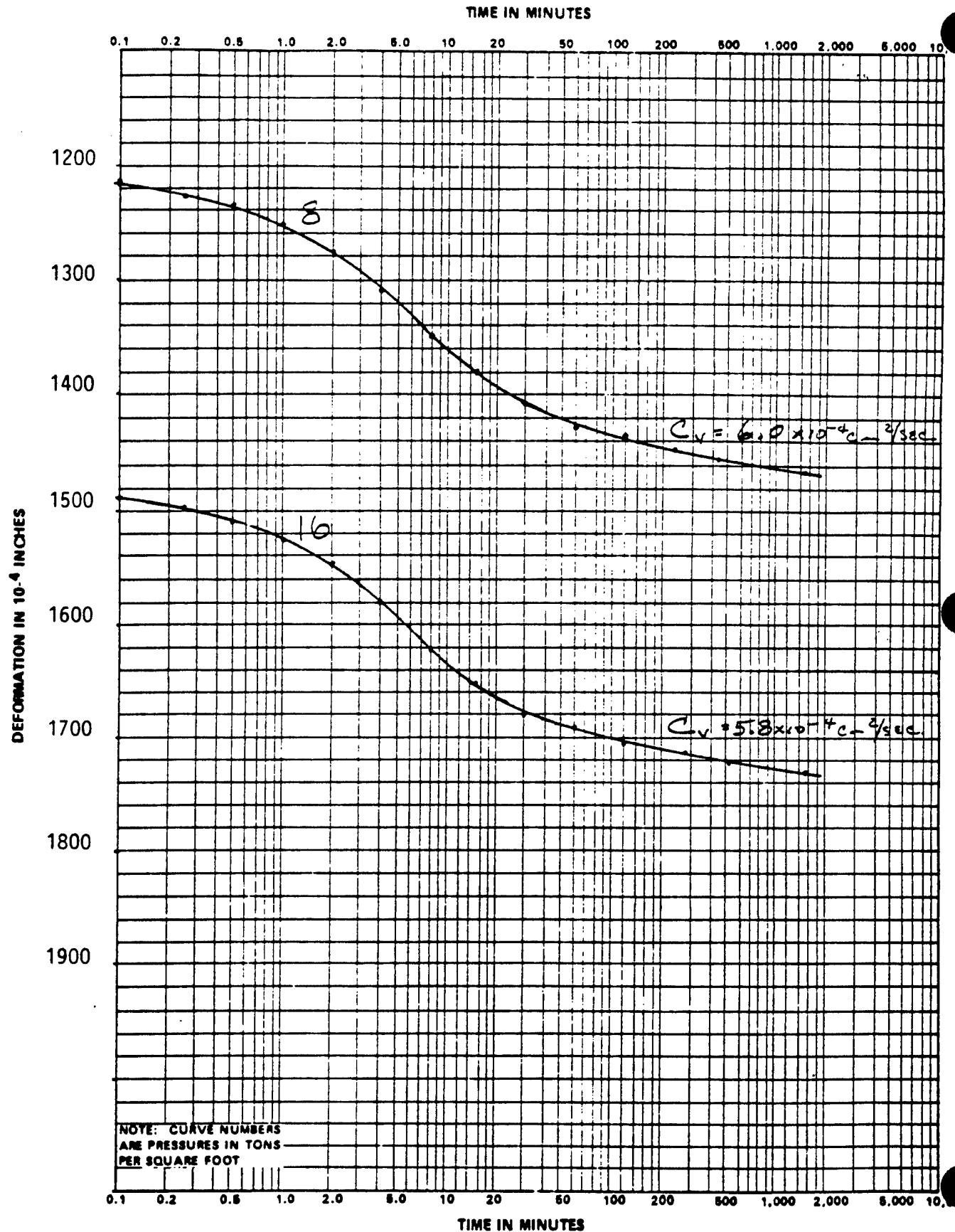
JOB NO.: 4220 88-226

SAMPLE NO.: 2

BORING NO.: 87-72M

DEPTH: 10'-12'

# CONSOLIDATION TEST TIME CURVES



PROJECT: CHASKA CREEK DIVERSION

JOB NO.: 4220 88-226 SAMPLE NO.: 2

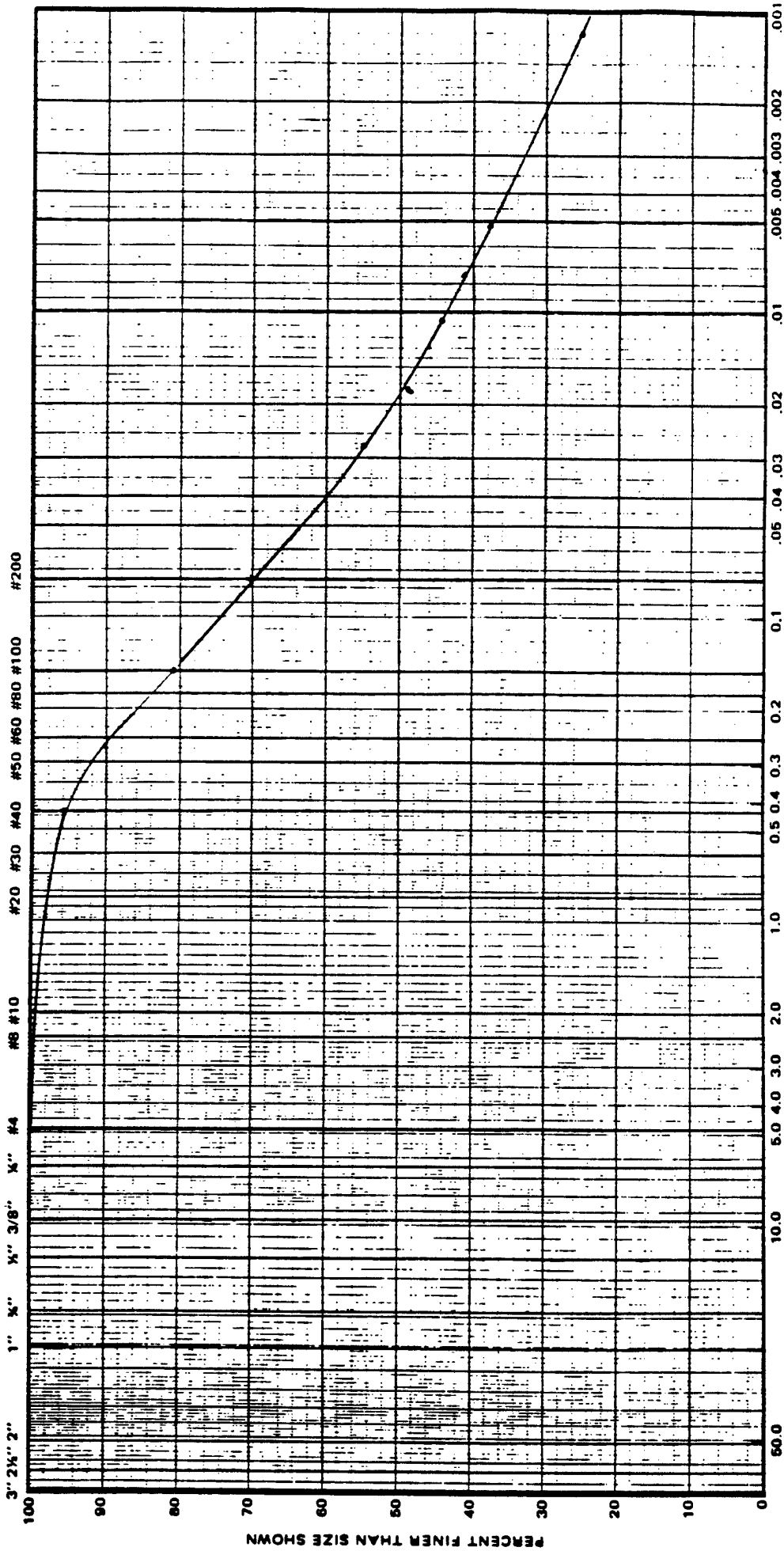
BORING NO.: 87-72M

DEPTH: 10'-12'

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE March 8, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-72M SAMPLE NO. 2 DEPTH (FT) 10-12 SOIL TYPE Fat Clay W/Sand (CH)

U.S. STANDARD SIEVE SIZES



PARTICLE SIZE IN MILLIMETERS

GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

# TRIAXIAL TEST DATA

Date March 3, 1988

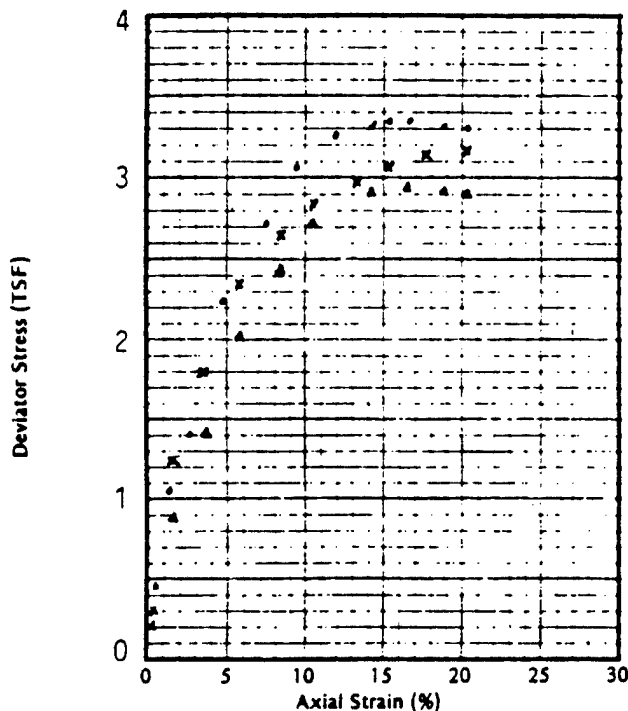
Job No. 4220 88-226

Project Chaska Creek Diversion

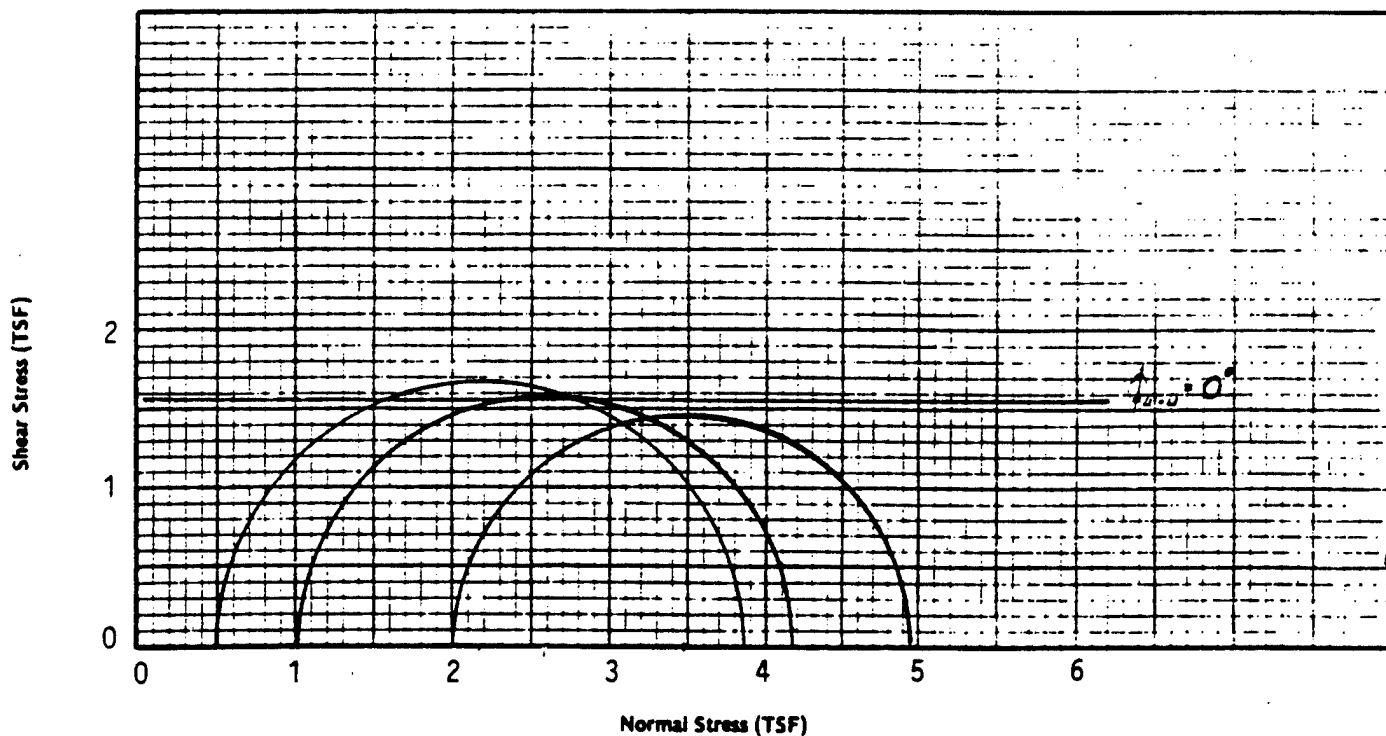
Boring No. 87-72M Sample No. 3 Depth (ft) 21-23 Type of Sample 5T

Soil Type Silty Clay (CL-ML/CL) Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage valves closed; stressed to given strains at constant rate of 0.060"/min.; Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	2.00	2.00	2.00	
	Height (inches)	4.23	4.22	4.22	
	Moisture Content (%)	23.4	23.7	23.5	
	Dry Density (PCF)	103.4	103.1	103.3	
	Saturation (%)	100	100	100	
	Void Ratio	0.61	0.61	0.61	
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF ( $\sigma_3$ )		0.50	1.00	2.00	
Maximum Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		3.34	3.18	2.94	
Ultimate Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )					
LL 28.1	PI 7.7				
PL 20.4	G <sub>s</sub> 2.67				



# TRIAXIAL TEST DATA

Date June 1988

Job No. 4220 88-226

Project Chaska Creek Division

Boring No. 87-72m

Sample No. 3

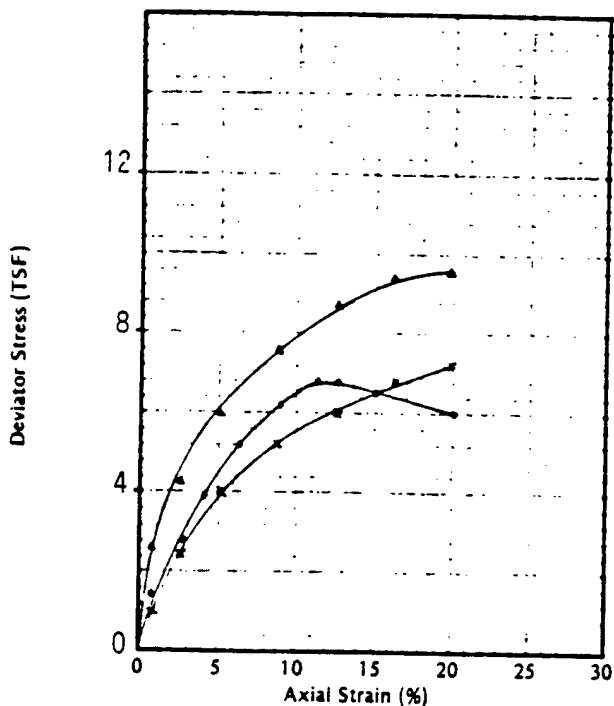
Depth (ft) 21-23

Type of Sample 5" Core

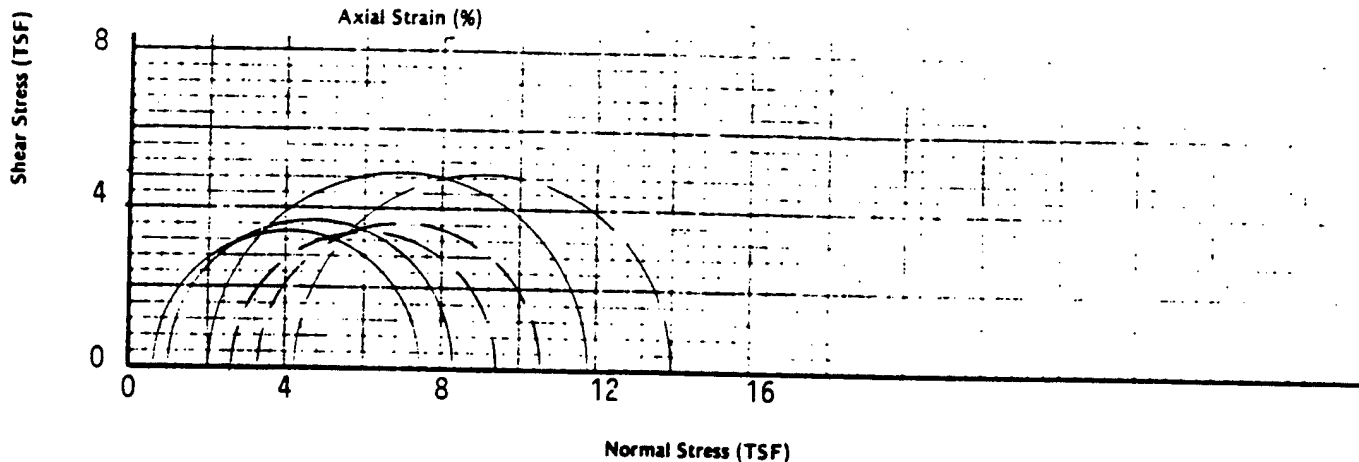
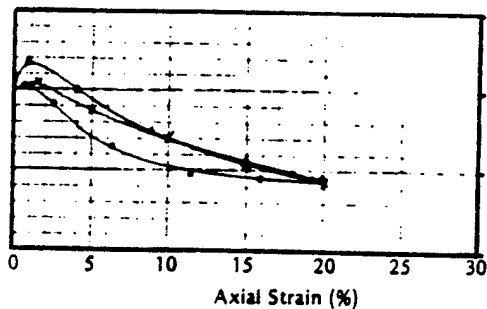
Soil Type Silty Clay (CL-ML)

Type of Test C-U w/pp

Remarks: Specimens trimmed to given sizes; radial (spiral) drainage strips applied; saturated for 20-26 days under low confinement; back pressure and effective confining pressures increased in stages, to values shown; then maintained for 17-19 days; stressed under constant strain rates of 0.006"/min; mohr circles at maximum stress ratio.

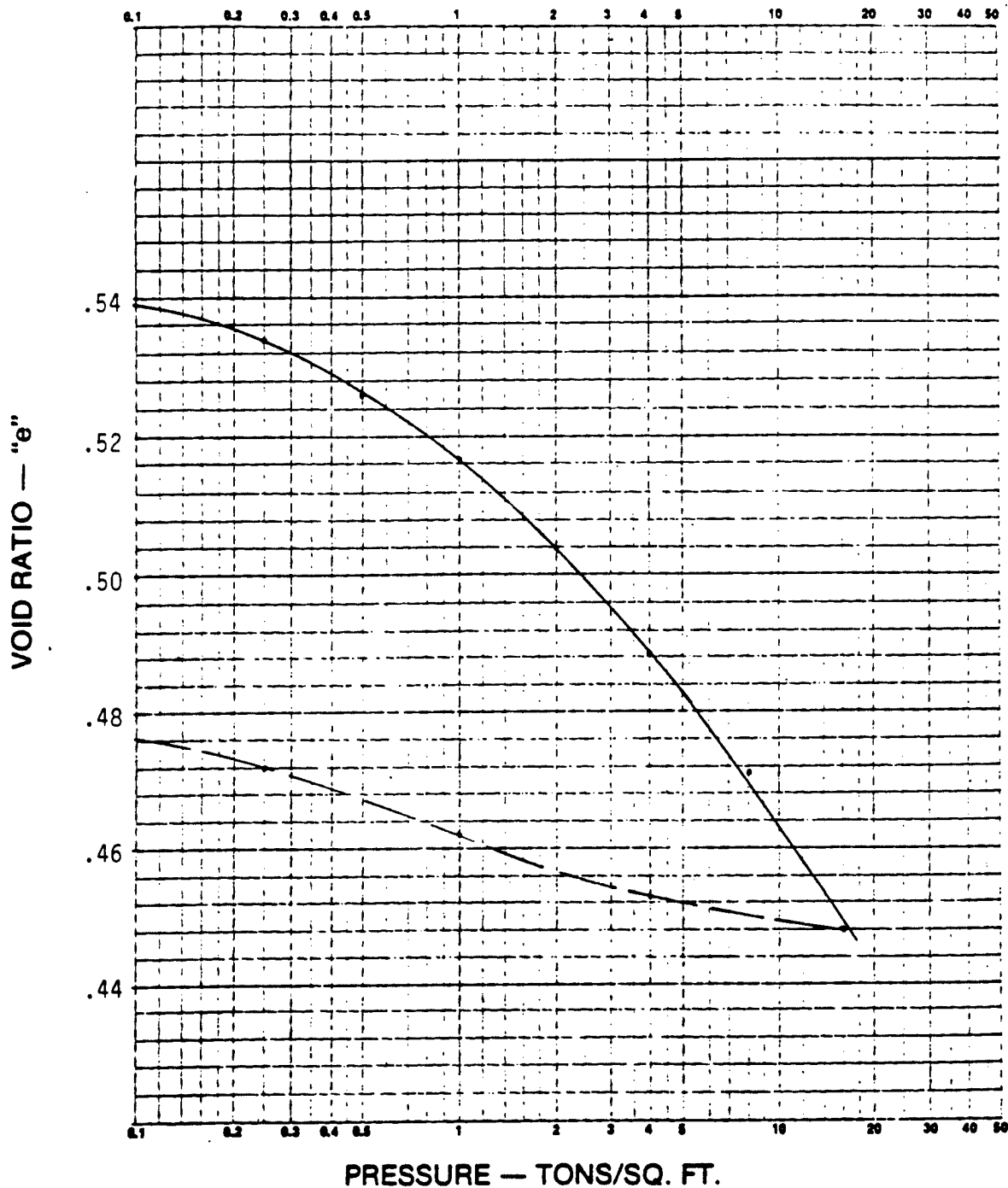


SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	2.00	2.00	2.00	
	Height (inches)	4.01	4.01	4.00	
	Moisture Content (%)	20.9	21.4	21.6	
	Dry Density (PCF)	106.2	105.3	105.0	
	Saturation (%)	98.1	97.7	98.2	
	Void Ratio	.57	.58	.58	
Before Shear	Moisture Content (%)	21.3	21.5	21.2	
	Dry Density (PCF)	106.3	106.0	106.5	
	Saturation (%)	98.9	100.0	99.8	
	Void Ratio	.57	.57	.57	
Back Pressure (TSF)		6.12	6.12	6.12	
Minor Principal Stress TSF		0.50	1.00	2.00	
Maximum Deviator Stress TSF		6.77	7.18	9.58	
Ultimate Deviator Stress TSF		6.0	7.2	9.6	
LL 28.1	PI 7.7				
PL 20.4	G <sub>s</sub> 2.67				



# CONSOLIDATION TEST CURVE

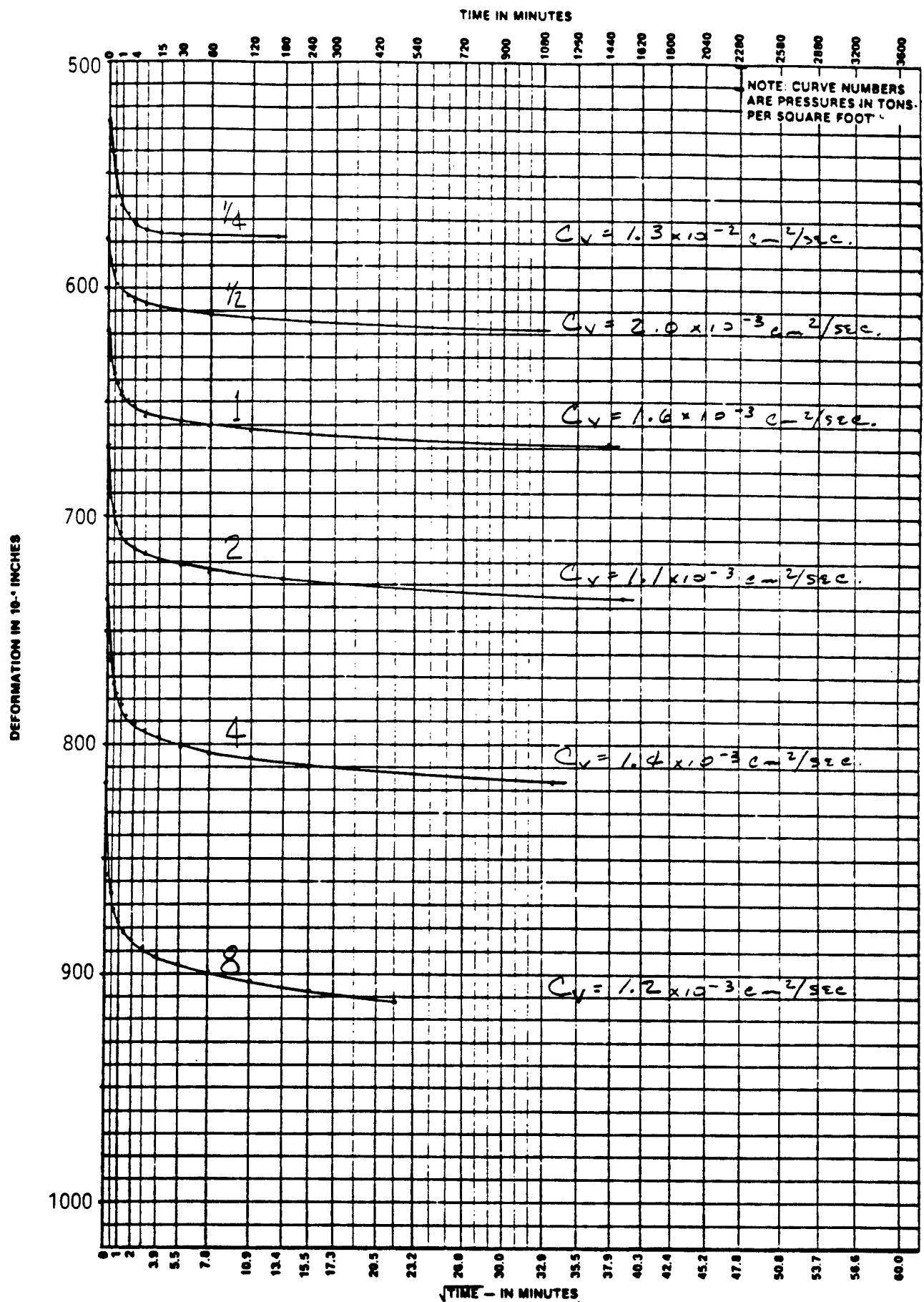
VOID RATIO VS. PRESSURE



Project Chaska Creek Diversion  
 Job No. 4220 88-226  $G_s = 2.67$  Date March 1, 1988  
 Boring No. 87-72M Soil Type (ASTM: D2487) Silty Clay (CL-ML/CL)  
 Sample No. 3 Original Moisture Content, Dry Density 21.8 % 107.9 PCF  
 Depth (FT.) 21-23 (Top) Liquid Limit 28.1 % Plastic Limit 20.4 %  
 Initial Sample Height (IN.) 0.799 Preconsolidation Pressure (Pc) 1.6 tsf  
 Sample Diameter (IN.) 2.501 Compression & Recompression Index:  $C_c$  0.07  $C_r$  \_\_\_\_\_



# CONSOLIDATION TEST TIME CURVES



PROJECT Chaska Creek Diversion

JOB. NO. 4220 88-226

SAMPLE NO. 3

BORING NO. 87-72M

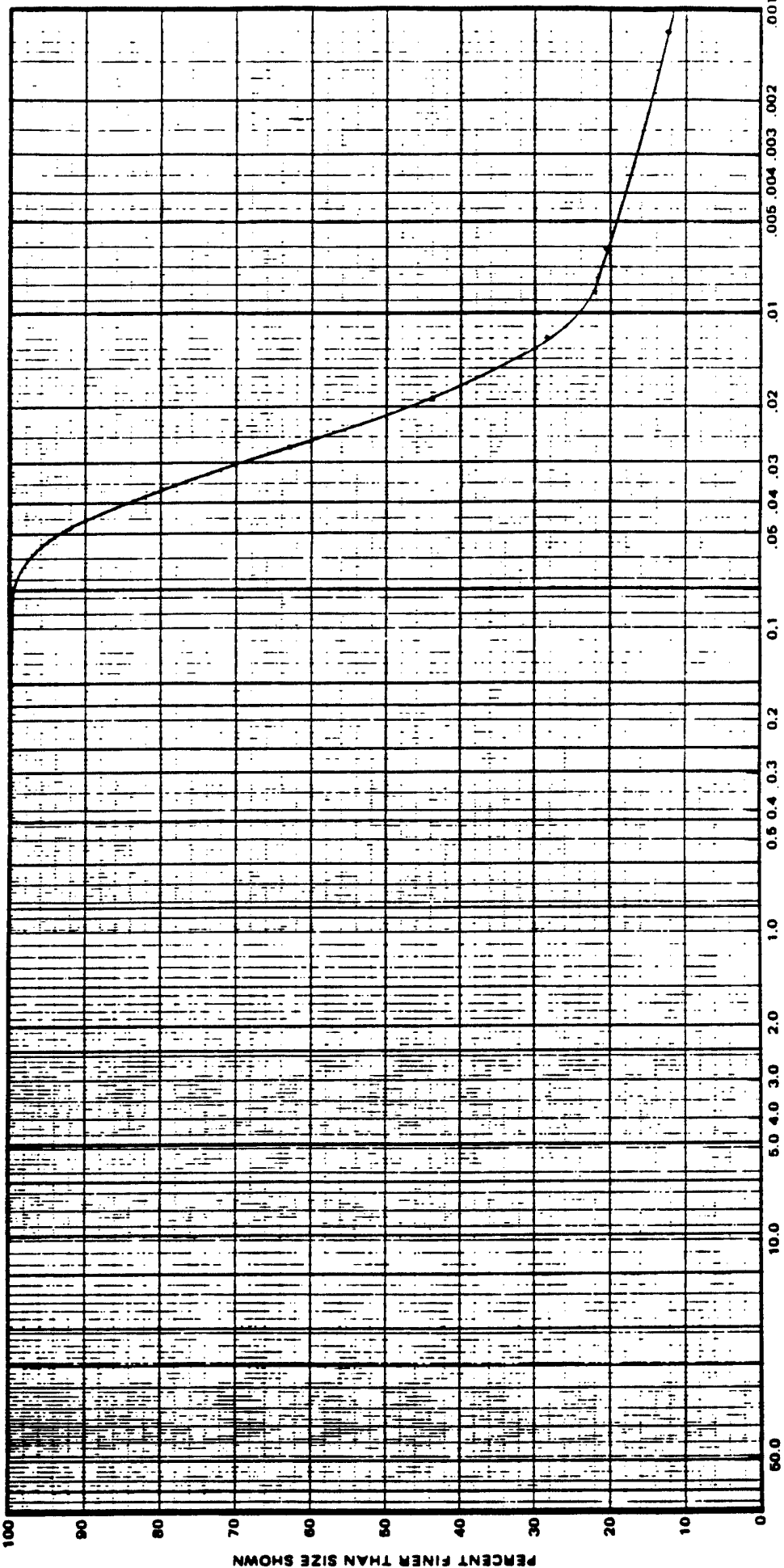
DEPTH 21'-23' (top)

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE March 8, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-72M SAMPLE NO. 3 DEPTH (FT) 21-23 SOIL TYPE Silty Clay (CL-ML/CL)

U.S. STANDARD SIEVE SIZES

3" 2 1/2" 2" 1" 3/4" 3/8" 1/2" #4 #8 #10 #20 #30 #40 #50 #60 #80 #100 #200



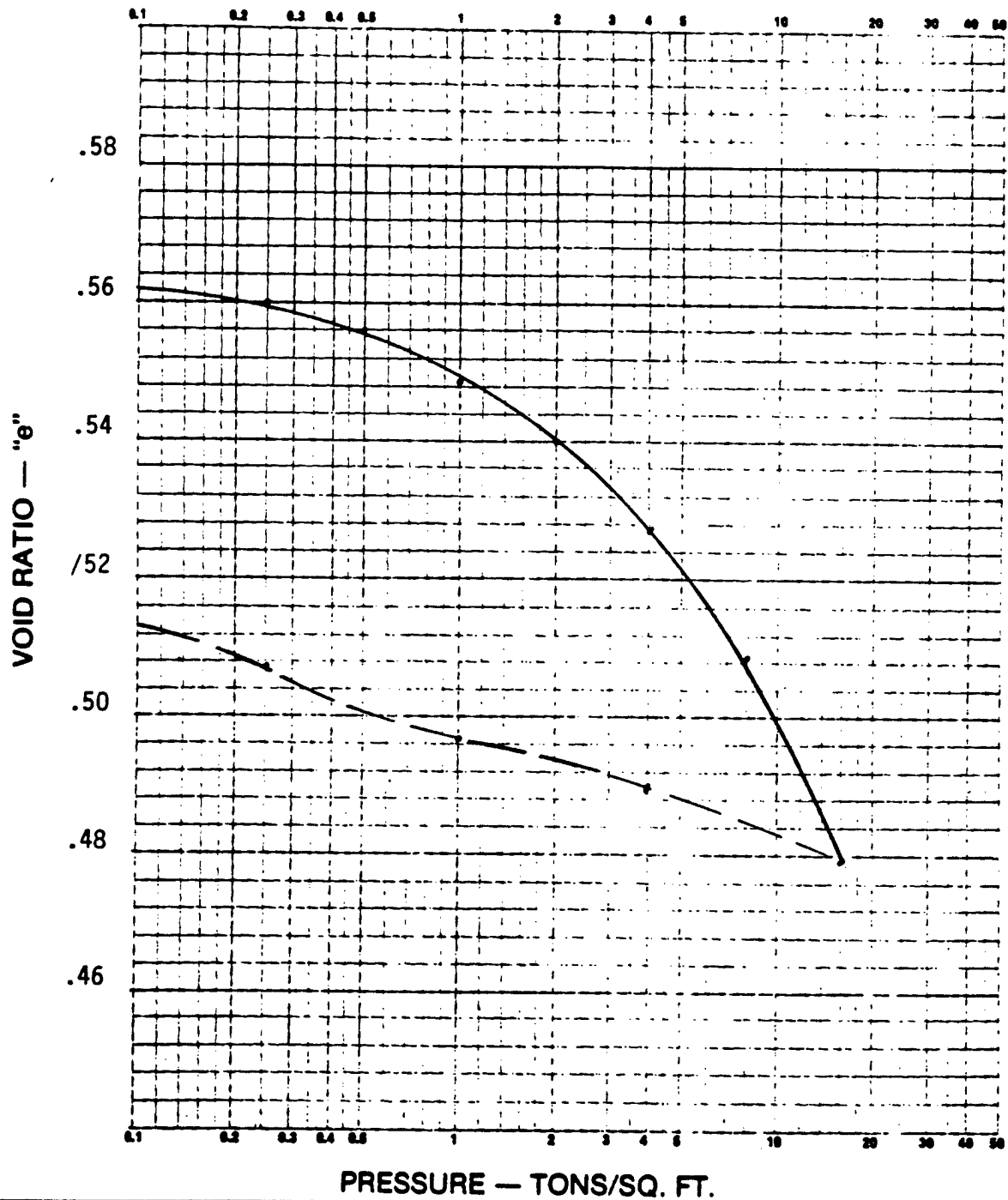
PARTICLE SIZE IN MILLIMETERS

GRAVEL: COARSE, FINE  
 SAND: MEDIUM, FINE  
 FINES

662 CROMWELL AVENUE  
 ST. PAUL, MN 55114  
 twin city testing corporation

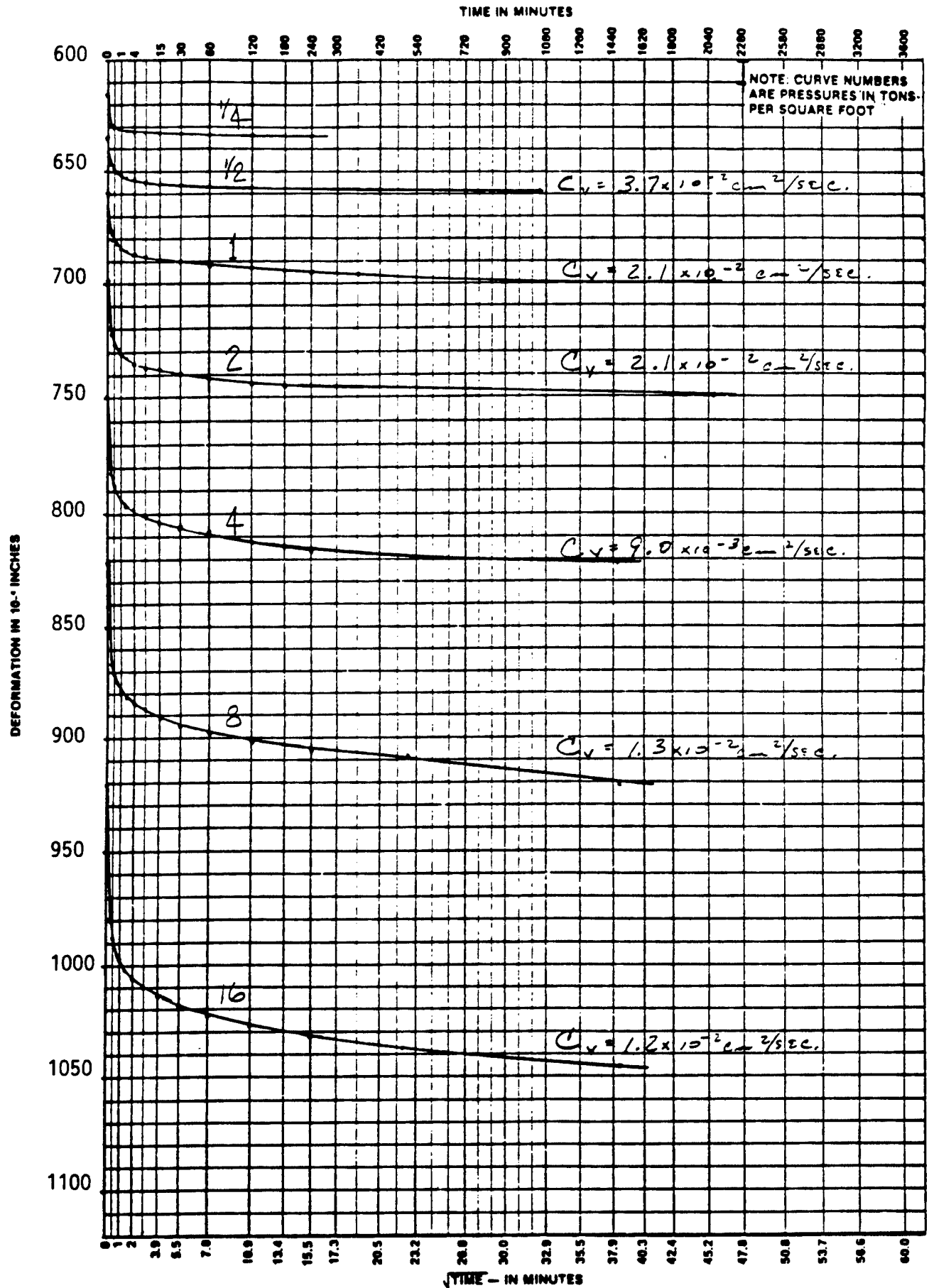
# CONSOLIDATION TEST CURVE

VOID RATIO VS. PRESSURE



Project <u>CHASKA CREEK DIVERSION</u>	
Job No. <u>4220 88-226</u>	GS = 2.68      Date <u>May 18, 1988</u>
Boring No. <u>87-72M</u>	Soil Type (ASTM: D2487) <u>Lean clay (CL)</u>
Sample No. <u>4</u>	Original Moisture Content, Dry Density <u>21.3</u> % <u>107.0</u> PCF
Depth (FT.) <u>28.0-29.4</u>	Liquid Limit <u>30.0</u> % Plastic Limit <u>16.5</u> %
Initial Sample Height (IN.) <u>0.797</u>	Preconsolidation Pressure (Pc) <u>2.7</u> tsf
Sample Diameter (IN.) <u>2.501</u>	Compression & Recompression Index: C <sub>c</sub> <u>0.07</u> C <sub>r</sub> <u>0.01</u>

# CONSOLIDATION TEST TIME CURVES



PROJECT CHASKA CREEK DIVERSION			
JOB. NO. 4220 88-226	SAMPLE NO. 4	BORING NO. 87-72M	DEPTH 28.0'-29.4'
662 CROMWELL AVENUE		TWIN CITY TESTING ST. PAUL, MN. 55114	

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT CHASKA CREEK DIVERSION

DATE May 18, 1988

REPORTED TO ST PAUL DISTRICT CORPS OF ENGINEERS

JOB NO. 4220 88-226

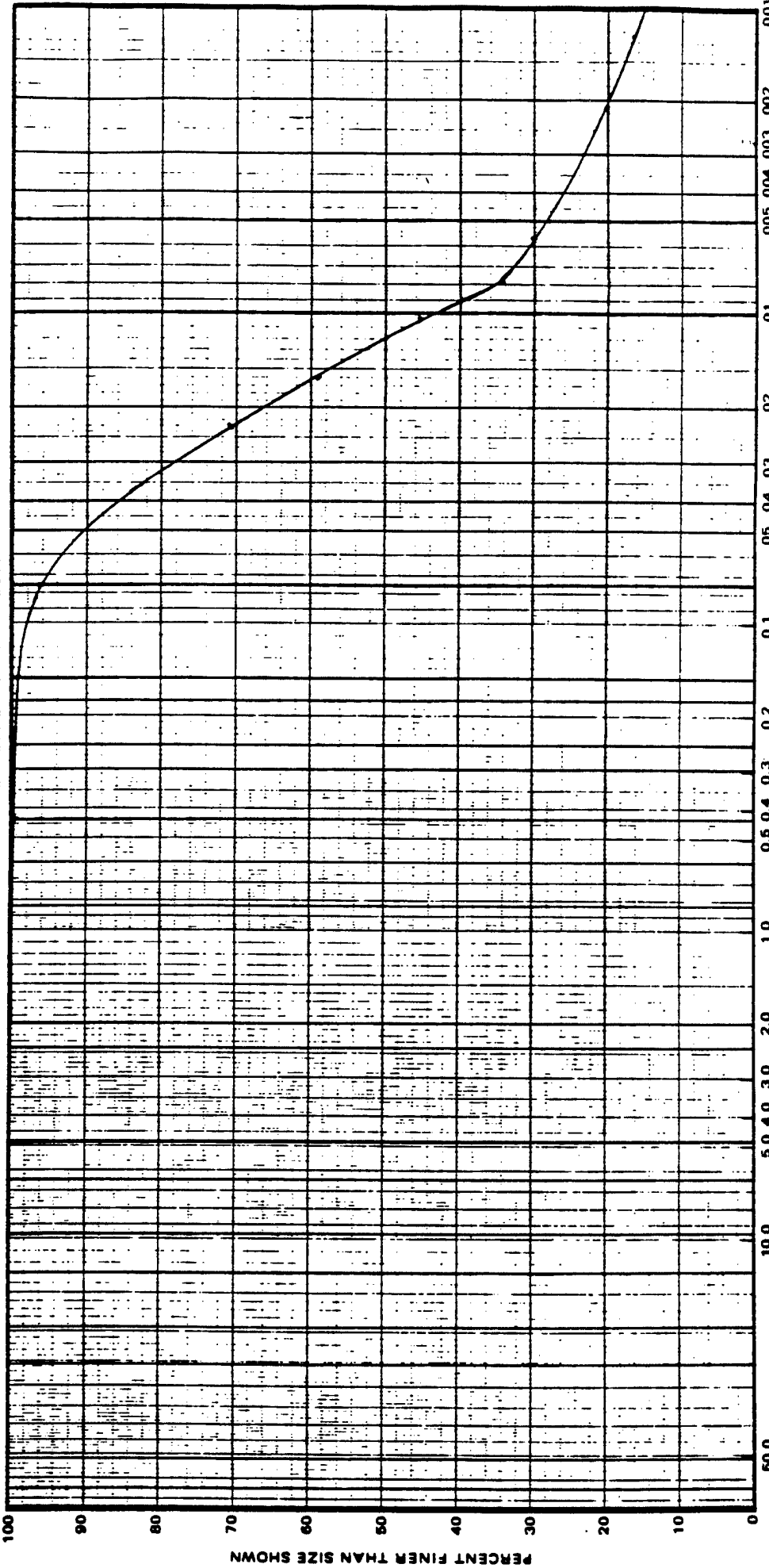
BORING NO. 87-72M SAMPLE NO. 4 DEPTH (FT) 28.0-29.4 SOIL TYPE Lean clay (CL)

U.S. STANDARD SIEVE SIZES

#20 #30 #40 #50 #60 #80 #100 #200

1" 3/4" 3/8" 1/4" #4 #8 #10

3" 2 1/2" 2"



PARTICLE SIZE IN MILLIMETERS

GRAVEL  
COARSE FINE

SAND  
MEDIUM FINE

FINES

# TRIAXIAL TEST DATA

Date March 3, 1988

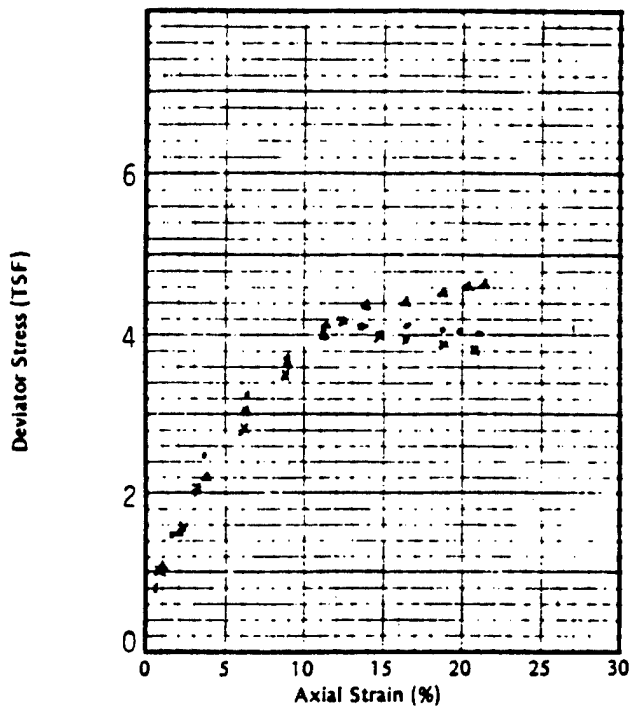
Job No. 4220 88-226

Project Chaska Creek Diversion

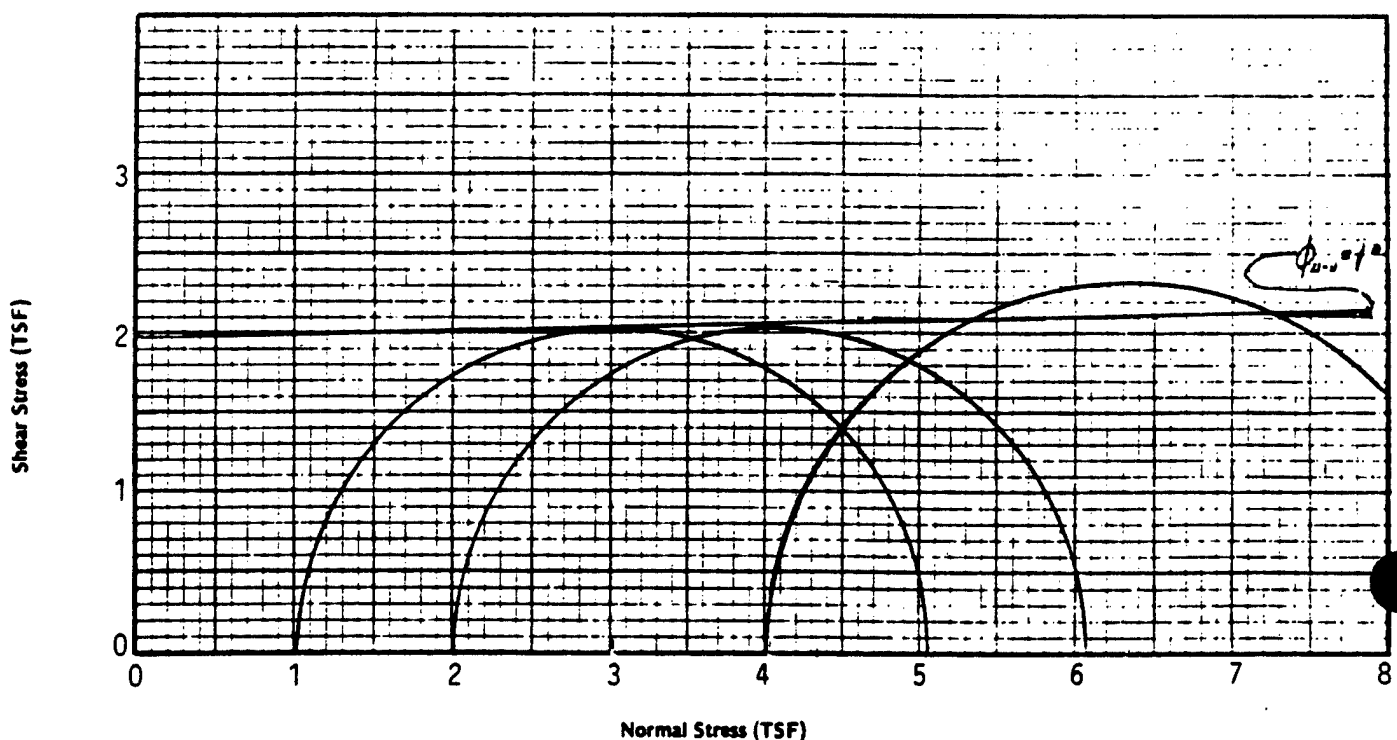
Boring No. 87-72M Sample No. 5 Depth (ft) 35-37 Type of Sample 5T

Soil Type Lean Clay (CL) Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage valves closed; stressed to given strains at constant rate of 0.060"/min.; Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.99	1.99	1.99	
	Height (inches)	4.03	4.05	3.99	
	Moisture Content (%)	22.0	22.5	22.8	
	Dry Density (PCF)	104.2	105.7	104.0	
	Saturation (%)	96.5	100	99.6	
	Void Ratio	0.62	0.59	0.62	
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF ( $\sigma_3$ )		1.00	2.00	4.00	
Maximum Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		4.06	4.10	4.66	
Ultimate Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )					
LL 37.4	PI 17.1				
PL 20.3	G <sub>s</sub> 2.70				



# TRIAXIAL TEST DATA

Date October 17, 1988

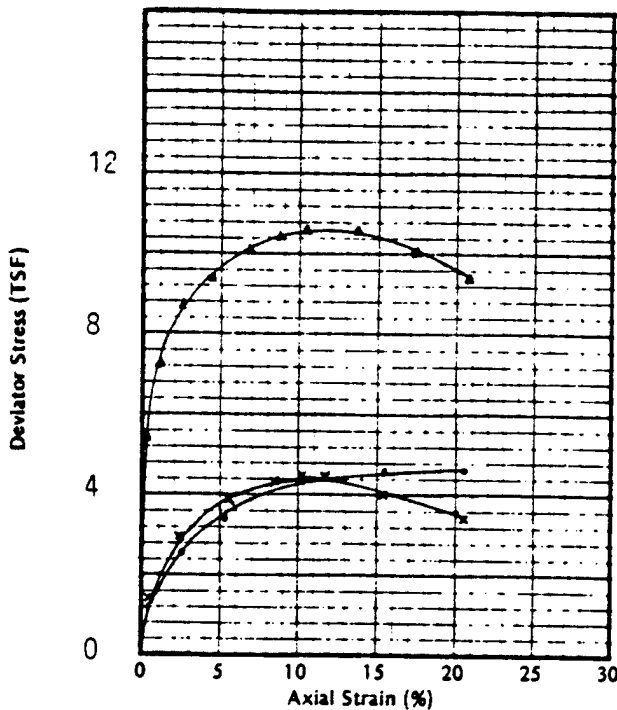
Job No. 4220 88-226

Project Chaska Creek Diversion

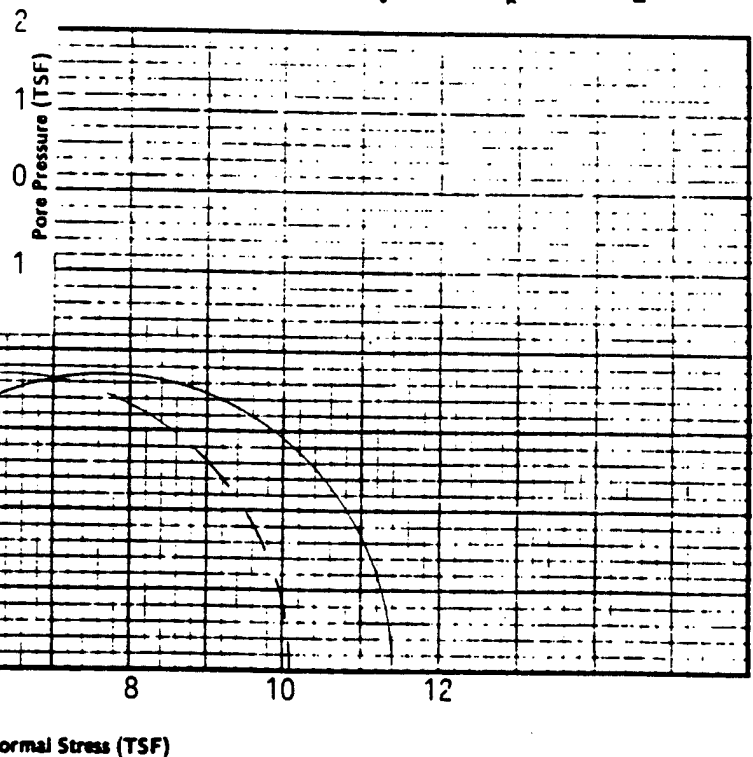
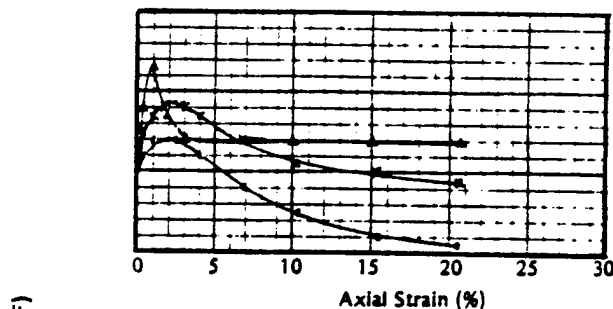
Boring No. 87-72m Sample No. 5 Depth (ft) 35-37 Type of Sample 5" Core

Soil Type Lean Clay (CL) Type of Test C-W w/pp

Remarks: Specimens trimmed to given sizes; radial (spiral) drainage strips applied; saturated for 26-36 days under low confinement; back pressure and effective confining pressures increased in stages, to values shown; then maintained for 17-22 days; stressed under constant strain rates of 0.006"/min; mohr circles at maximum stress ratio.

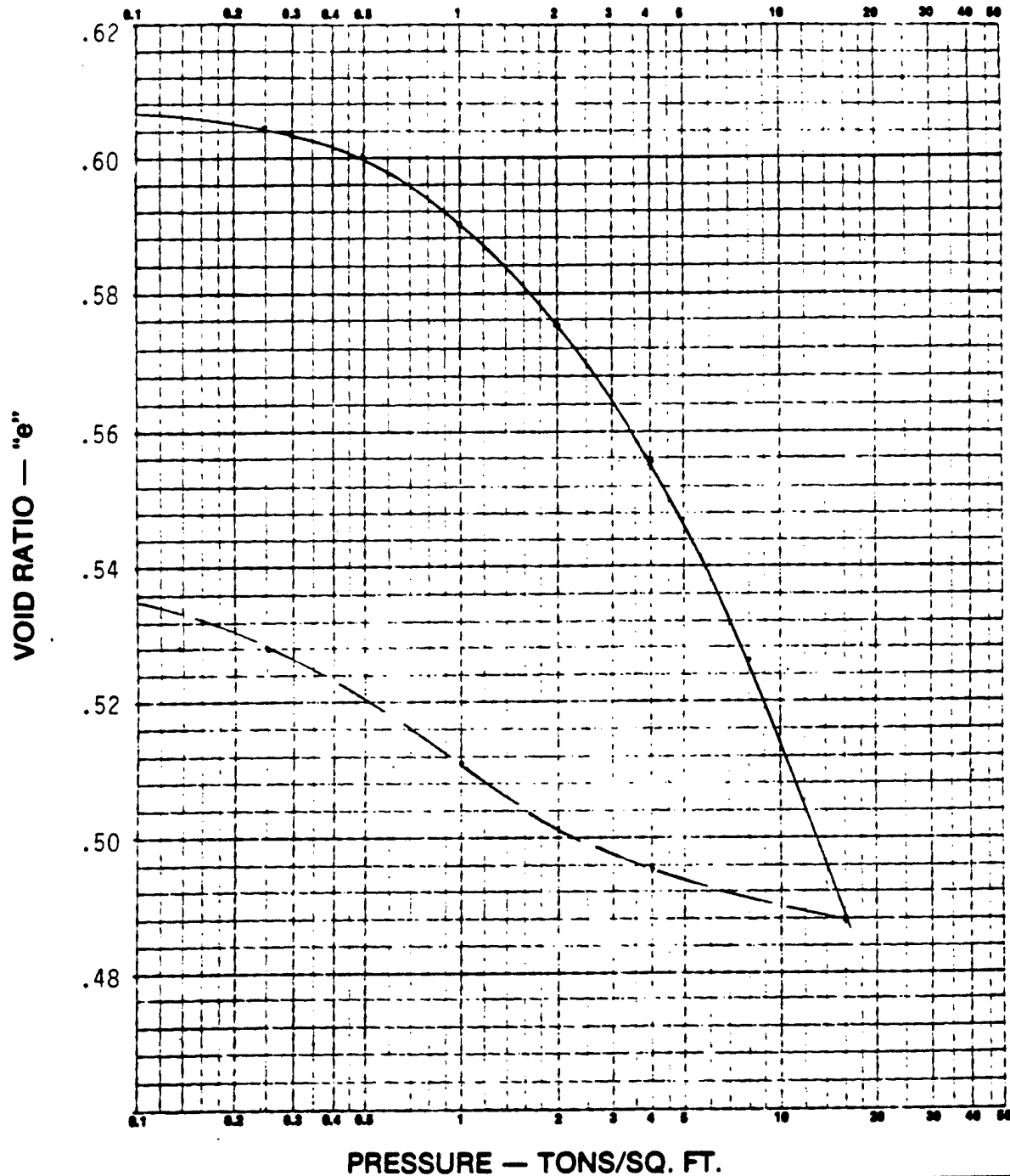


SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.41	1.41	1.41	
	Height (inches)	2.95	2.95	2.93	
	Moisture Content (%)	20.2	13.6	14.8	
	Dry Density (PCF)	106.6	102.2	100.8	
	Saturation (%)	93.8	98.4	99.8	
	Void Ratio	.58	.65	.67	
Before Shear	Moisture Content (%)	20.8	22.4	22.2	
	Dry Density (PCF)	107.8	104.9	105.3	
	Saturation (%)	99.5	99.6	99.9	
	Void Ratio	.56	.61	.60	
	Back Pressure (TSF)	6.12	6.12	6.12	
Minor Principal Stress TSF ( $\sigma_3$ )		1.00	2.00	4.00	
Maximum Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		4.67	4.35	10.52	
Ultimate Deviator Stress TSF ( $\sigma_1 - \sigma_3$ )		4.7	3.6	9.5	
LL	37.4	PI	17.1		
PL	20.3	G <sub>s</sub>	2.70		



# CONSOLIDATION TEST CURVE

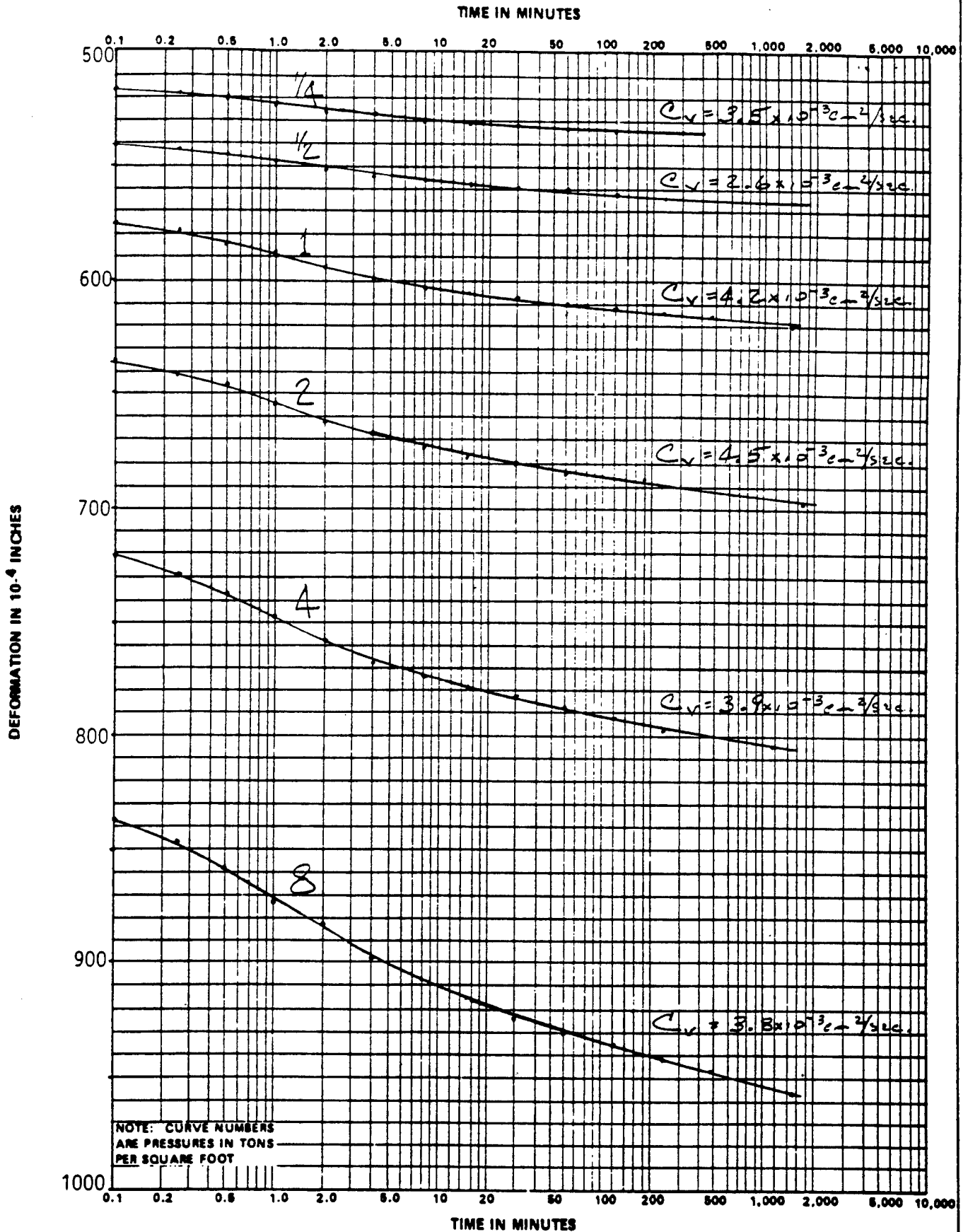
VOID RATIO VS. PRESSURE



Project <u>Chaska Creek Diversion</u>		Date <u>March 1, 1988</u>	
Job No. <u>4220 88-226</u>	$G_s = 2.69$	Soil Type (ASTM: D2487) <u>Lean Clay (CL)</u>	
Boring No. <u>87-72M</u>		Original Moisture Content, Dry Density <u>22.9</u> % <u>104.6</u> PCF	
Sample No. <u>5</u>		Liquid Limit <u>37.4</u> % Plastic Limit <u>20.3</u> %	
Depth (FT.) <u>35-37 (Top)</u>		Preconsolidation Pressure (Pc) <u>1.7 tsf</u>	
Initial Sample Height (IN.) <u>0.797</u>		Compression & Recompression Index: $C_c$ <u>0.10</u> $C_r$ _____	
Sample Diameter (IN.) <u>2.505</u>			



# CONSOLIDATION TEST TIME CURVES



PROJECT: Chaska Creek Diversion

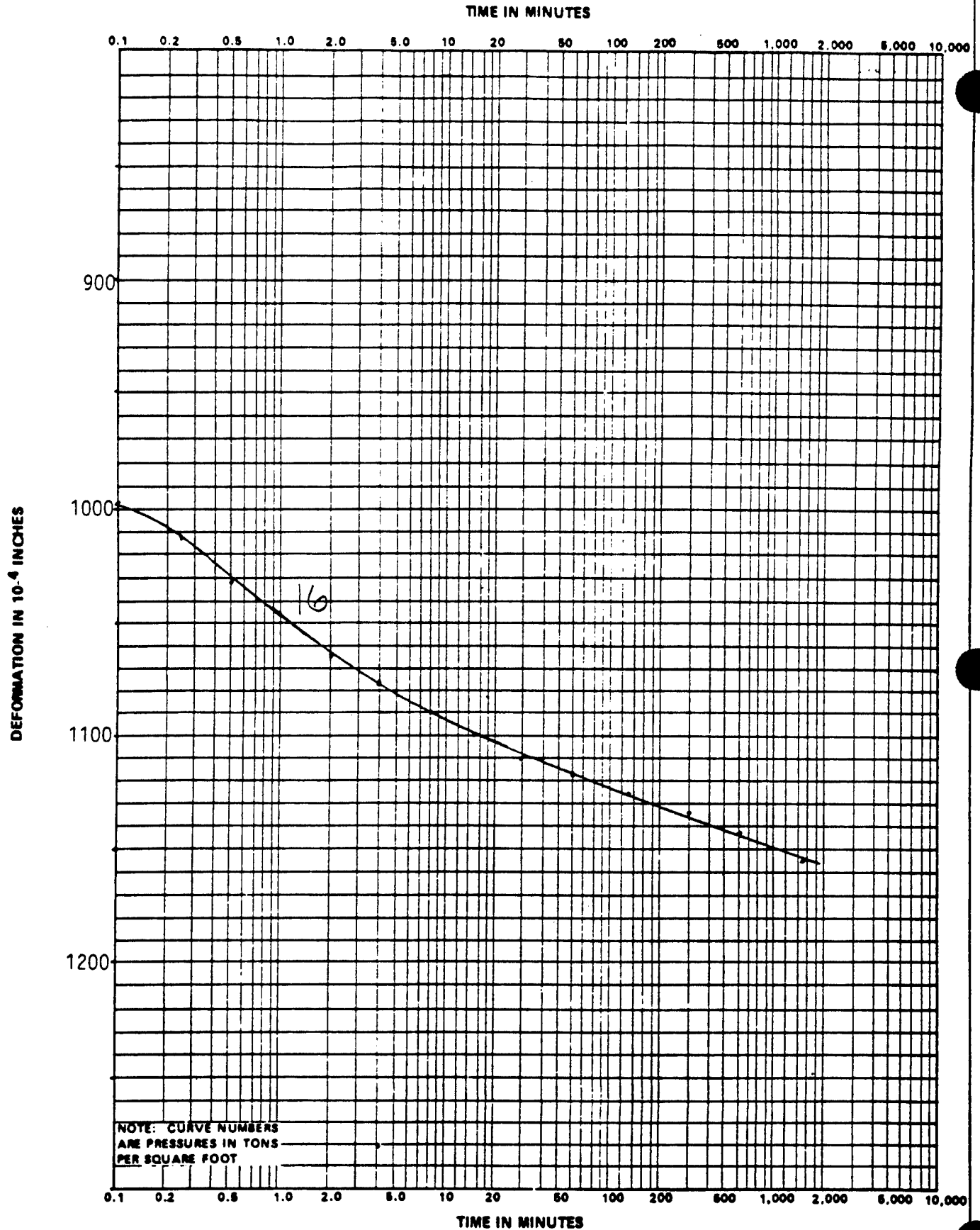
JOB NO.: 4220 88-226

SAMPLE NO.: 5

BORING NO.: 87-72M

DEPTH: 35.0'-37.0' (Top)

# CONSOLIDATION TEST TIME CURVES



PROJECT: Chaska Creek Diversion

JOB NO.: 4220 88-226

SAMPLE NO.: 5

BORING NO.: 87-72M

DEPTH: 35.0'-37.0' (Top)

SL-17 (77-8)

662 CROMWELL AVENUE



twin city testing  
corporation

ST. PAUL, MN. 55114

Figure C-182



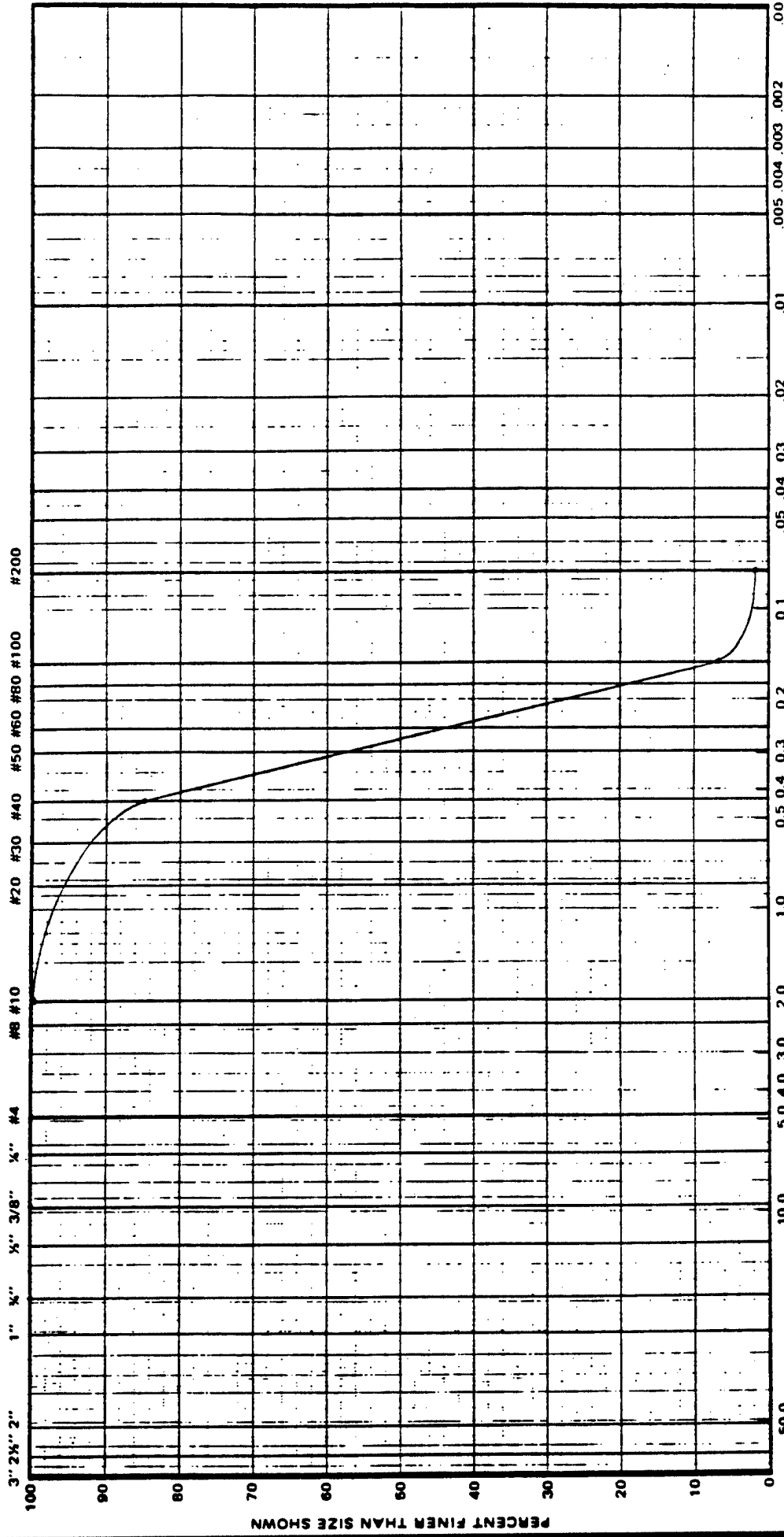
# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 17, 1988

REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226

BORING NO. 87-72M SAMPLE NO. 6 DEPTH (FT) 15.4-15.9 SOIL TYPE Sand, Fine Grained (SP)

U.S. STANDARD SIEVE SIZES



PARTICLE SIZE IN MILLIMETERS

FINES

SAND

FINE

GRAVEL

FINE

COARSE

MEDIUM

SAND

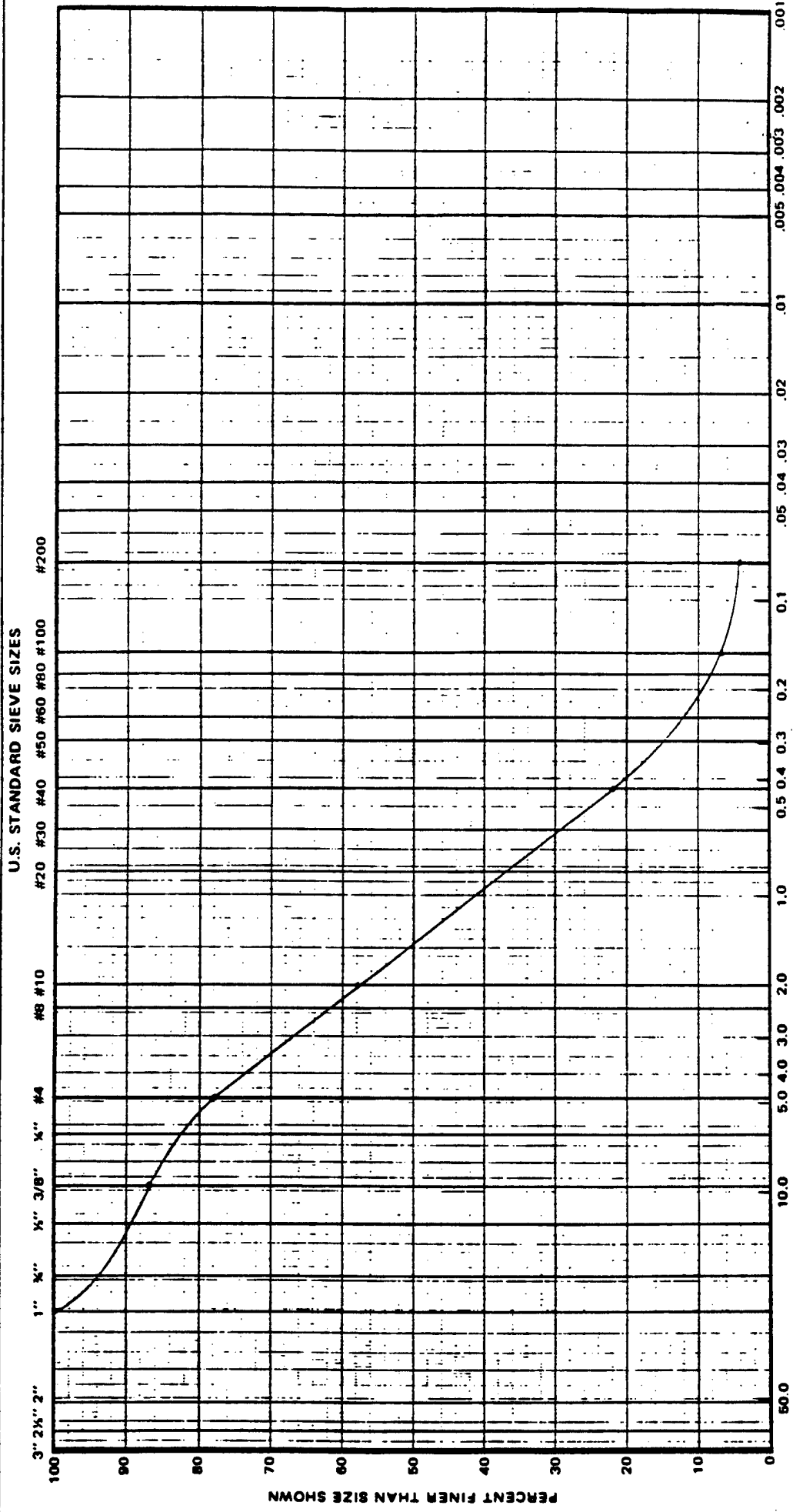
ST. PAUL, MN. 55114

TWIN CITIES  
CORPORATION

662 CROMWELL AVENUE

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 17, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-72M SAMPLE NO. 15 DEPTH (FT) 50.3-50.9 SOIL TYPE Sand W/Gravel, Medium to Coarse Grained (SP)



GRAVEL			SAND			FINES		
COARSE	FINE		COARSE	MEDIUM	FINE			

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion

DATE February 17, 1988

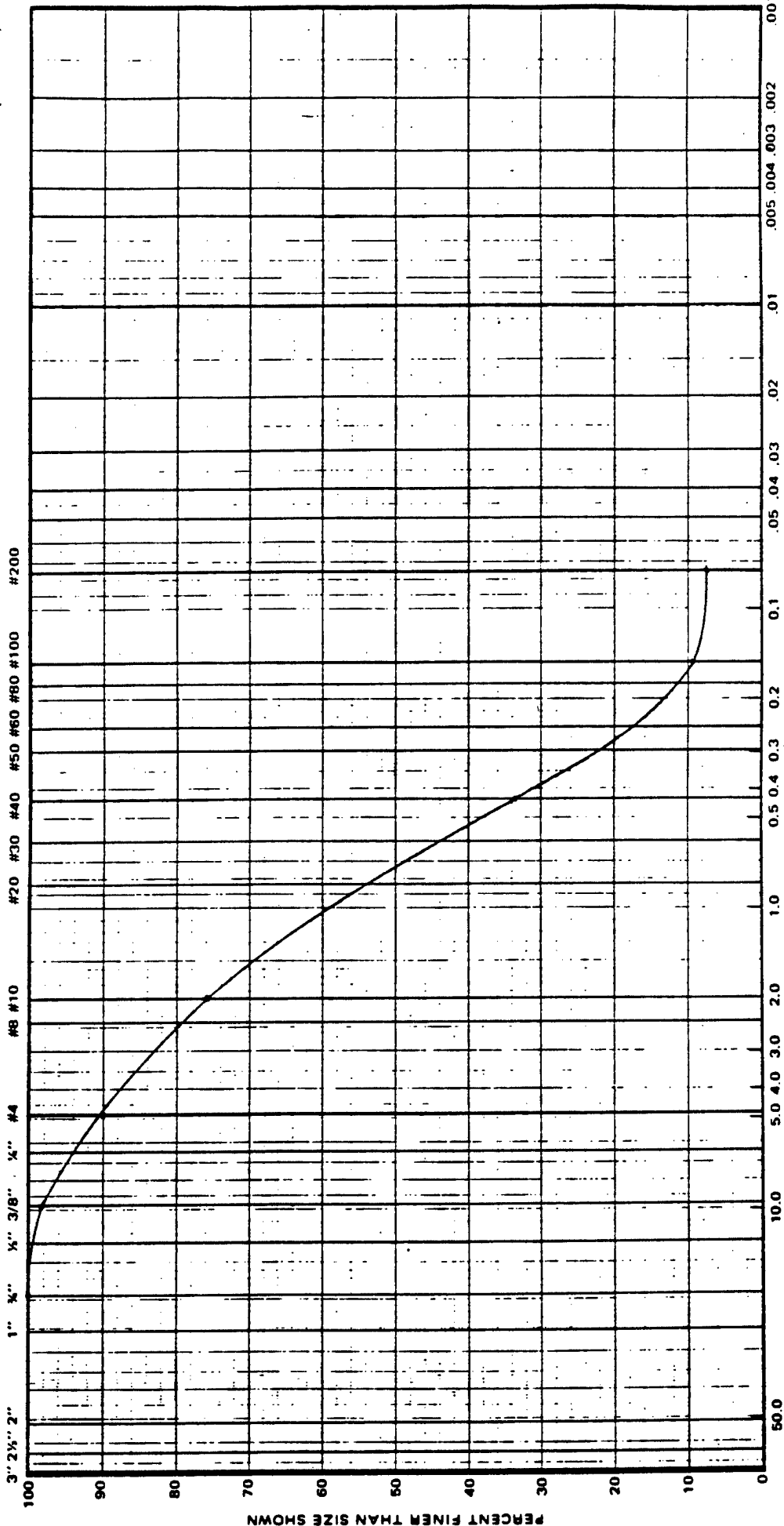
REPORTED TO St. Paul District Corps of Engineers

JOB NO. #4220 88-226

BORING NO. 87-72M SAMPLE NO. 18 DEPTH (FT) 66.2-66.9 SOIL TYPE Sand W/Silt & A Little Gravel, Medium Grained

(SP-SM)

U.S. STANDARD SIEVE SIZES



GRAVEL FINE MEDIUM COARSE SAND FINE

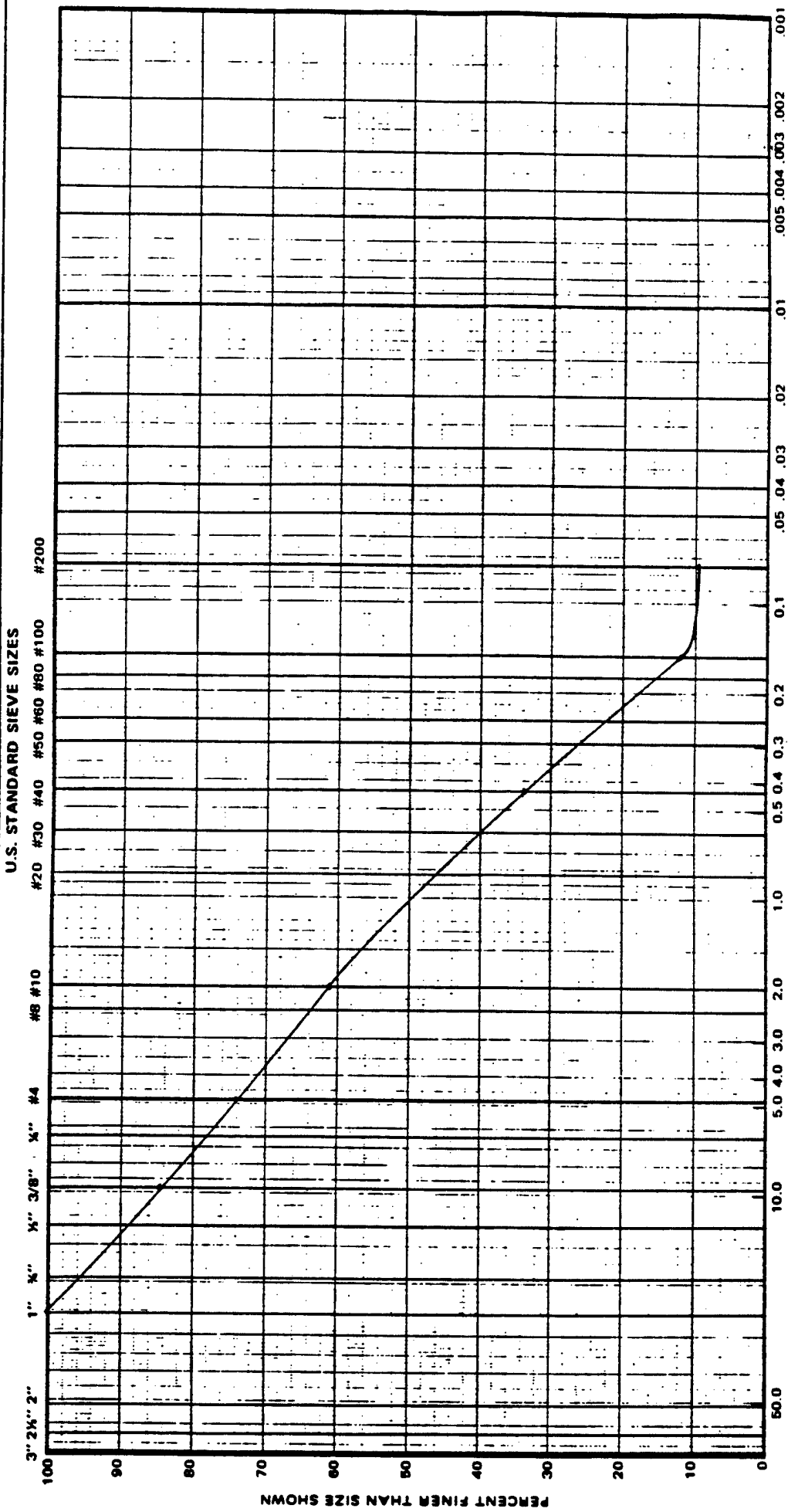
FINES

662 CROMWELL AVENUE ST. PAUL, MN. 55114

TESTING CORPORATION

# GRAIN SIZE DISTRIBUTION CURVE

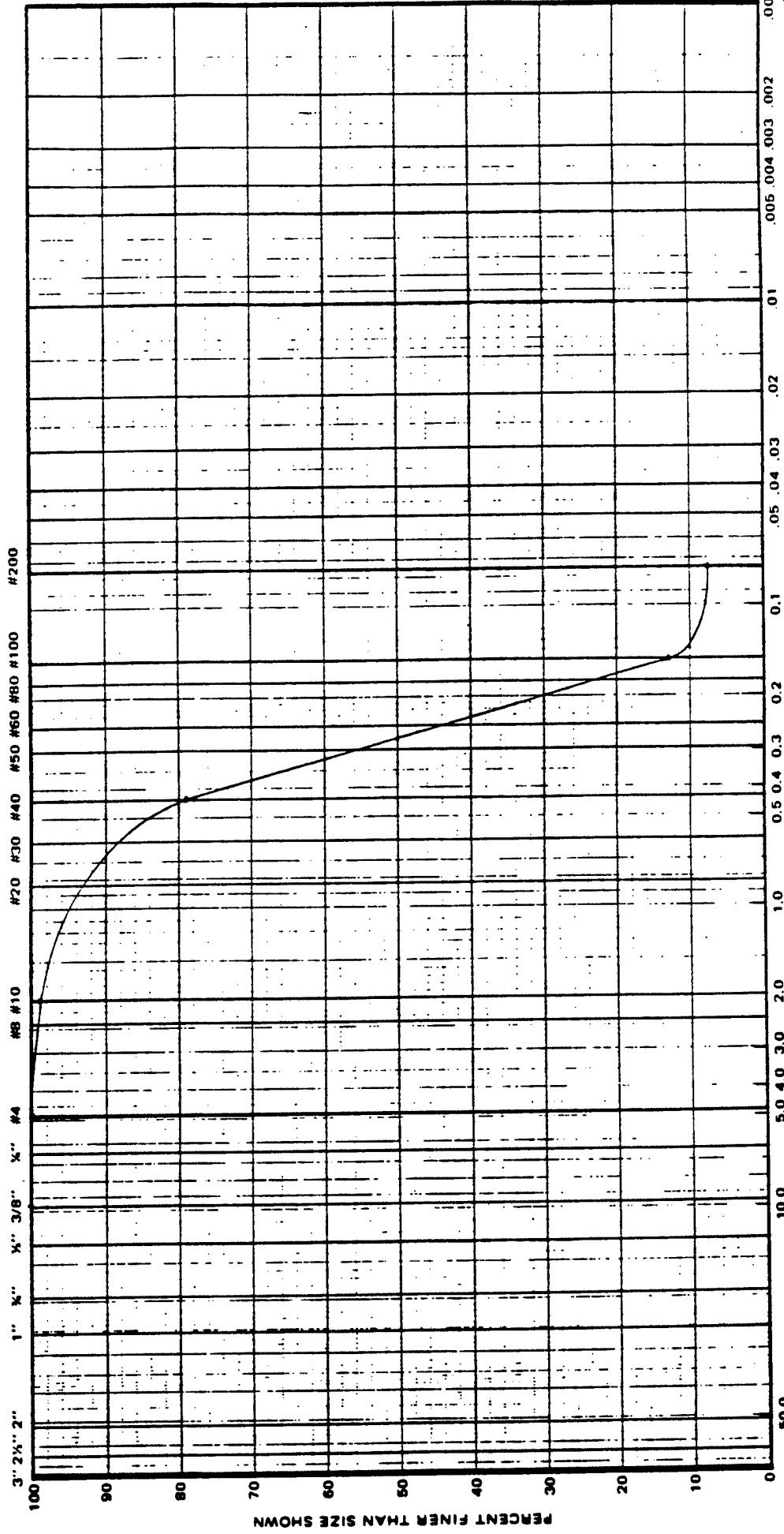
PROJECT Chaska Creek Diversion DATE February 17, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-72M SAMPLE NO. 24 DEPTH (FT) 86.2-86.8 SOIL TYPE Sand W/Silt & Gravel, Medium Grained (SP-SM)



# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 17, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-72M SAMPLE NO. 27 DEPTH (FT) 98.5-99.1 SOIL TYPE Sand W/Silt, Fine Grained (SP-SM)

U.S. STANDARD SIEVE SIZES





## INDEX TESTS

PROJECT: Chaska Creek Diversion

DATE: March 9, 1988

REPORTED TO: St. Paul District Corps of Engineers

JOB NO.: #4220 88-226

BORING #87-72M

SAMPLE NO.	DEPTH (ft)	SYMBOL	WATER CONTENT (%)	ATTERBURG LIMITS		
				Liquid Limit	Plastic Limit	Plasticity Index
9	26.3 - 26.8	(CL)	13.1	32.2	21.6	10.6
10	33.2 - 33.8	(CL)	18.0	40.0	20.1	19.9
11	38.1 - 38.8	(CL)	25.1	43.9	21.1	22.8
20	76.7 - 78.2	(CH)	24.7	60.1	23.1	37.0



# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion

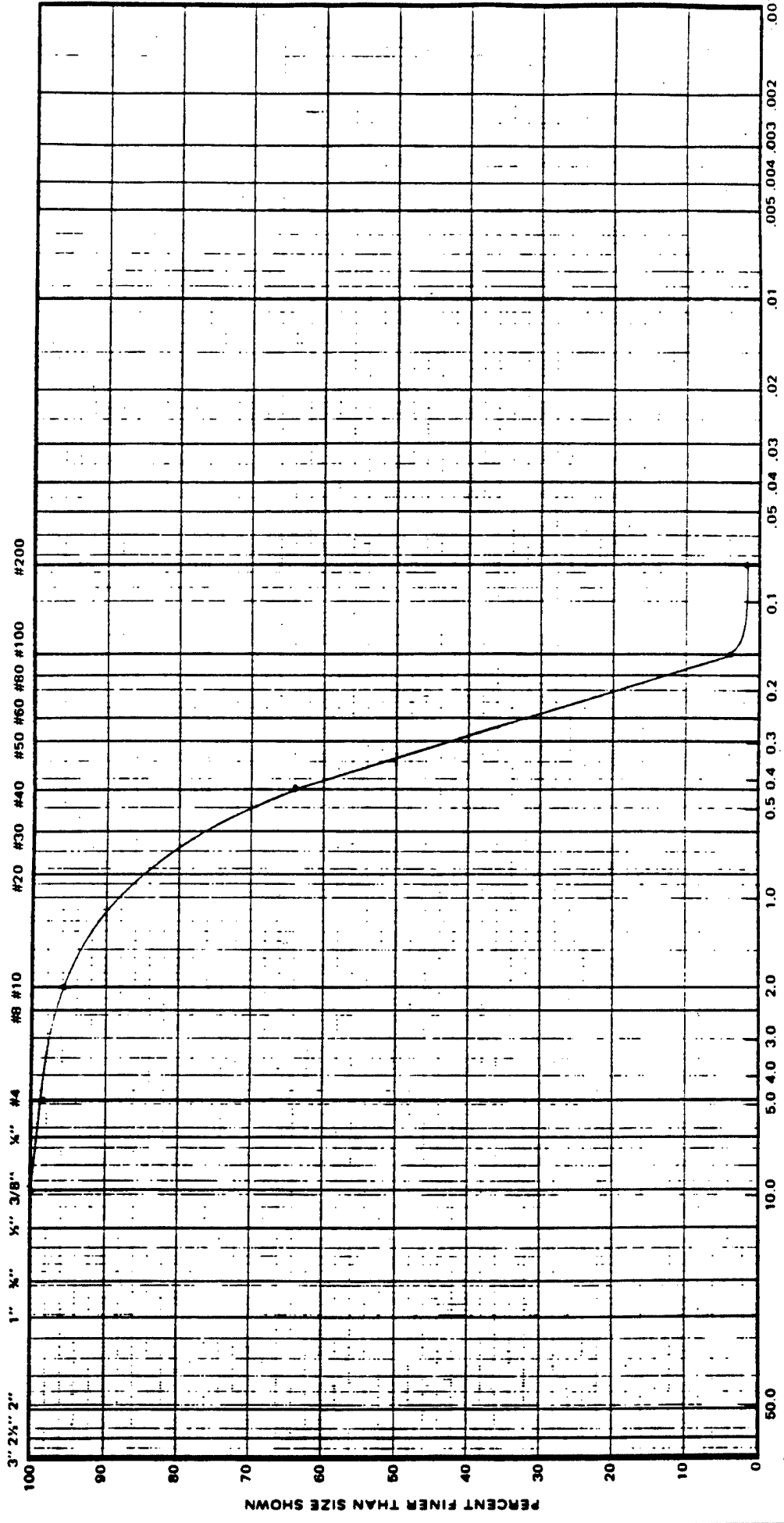
DATE February 6, 1988

REPORTED TO St. Paul District Corps of Engineers

JOB NO. 4220 88-226

BORING NO. 87-75M SAMPLE NO. 1 DEPTH (FT) 3.2-3.9 SOIL TYPE Sand, Fine Grained (SP)

U.S. STANDARD SIEVE SIZES



PARTICLE SIZE IN MILLIMETERS

GRAVEL

COARSE

FINE

SAND

MEDIUM

FINE

FINES

# TRIAXIAL TEST DATA

Date August 17, 1988

Job No. 4220 88-226

Project Chaska Creek Diversion

Boring No. 87-75M

Sample No. 2

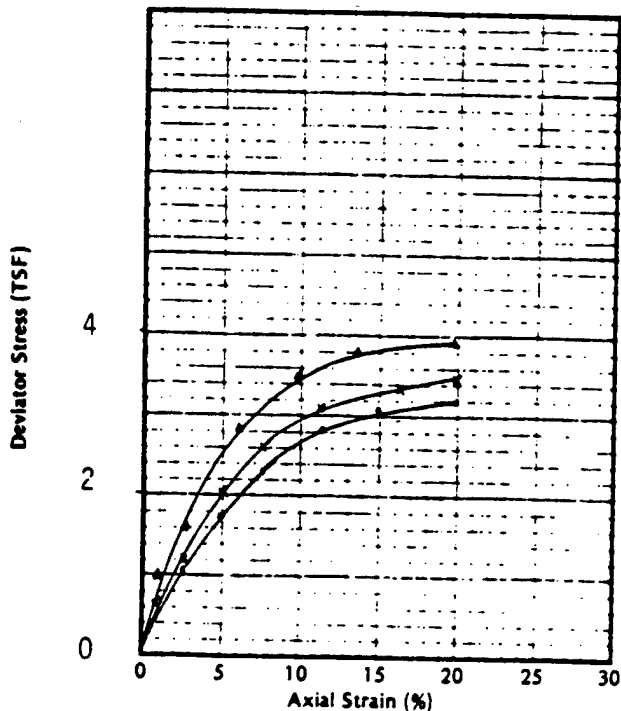
Depth (ft) 33-35


Type of Sample 5" Core

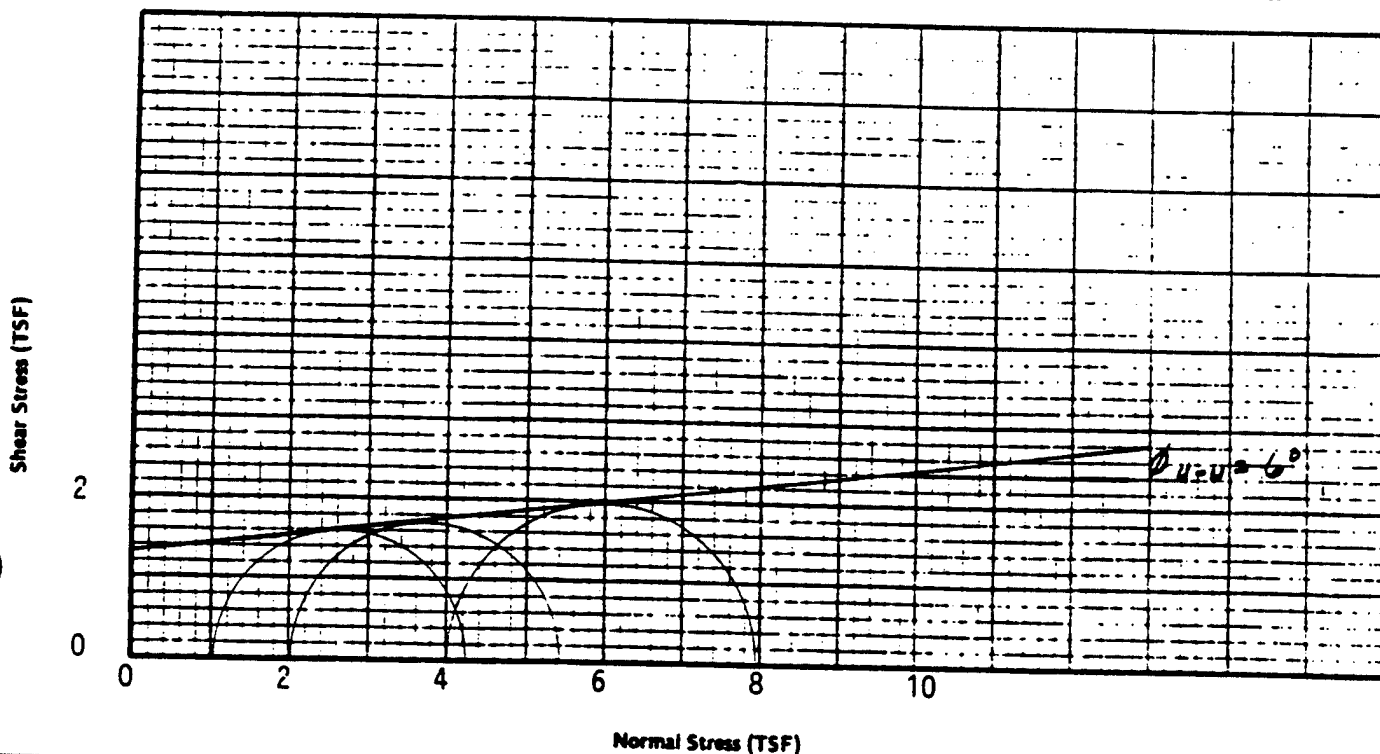
Soil Type Lean Clay (CL)

Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage values closed; stressed to given strains at constant rate of 0.060"/min. Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	2.00	1.99	1.99	
	Height (inches)	4.06	4.02	4.08	
	Moisture Content (%)	25.3	24.5	24.4	
	Dry Density (PCF)	101.0	101.6	101.6	
	Saturation (%)				
Before Shear	Void Ratio				
	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
Back Pressure (TSF)	Minor Principal Stress TSF $\sigma_3'$	1.0	2.0	4.0	
	Maximum Deviator Stress TSF $\sigma_1 - \sigma_3'$	3.21	3.45	3.97	
	Ultimate Deviator Stress TSF $\sigma_1 - \sigma_3'$	3.2	3.5	4.0	
LL	PI				
PL	G <sub>s</sub> 2.68				



# TRIAXIAL TEST DATA

Date July 8, 1988

Job No. 4220 88-226

Project Chaska Circle Diversion

Boring No. 87-75M

Sample No. 2

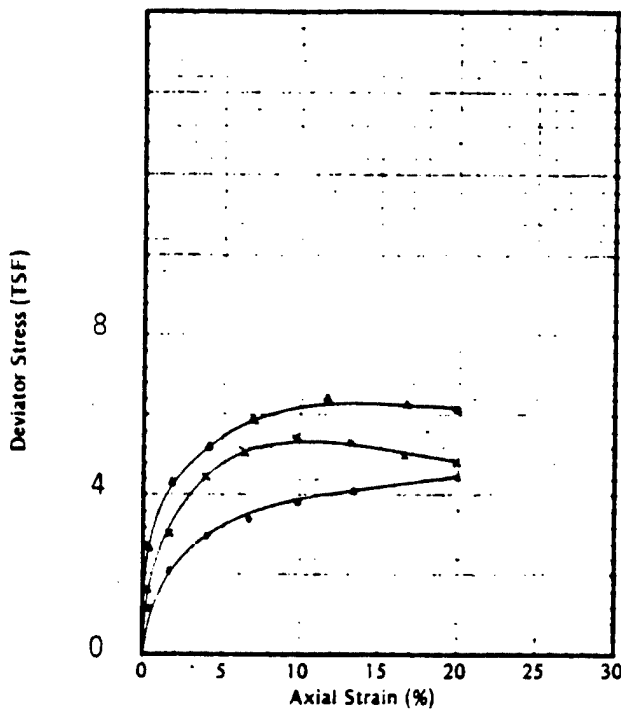
Depth (ft) 33-35

Type of Sample 5" Core

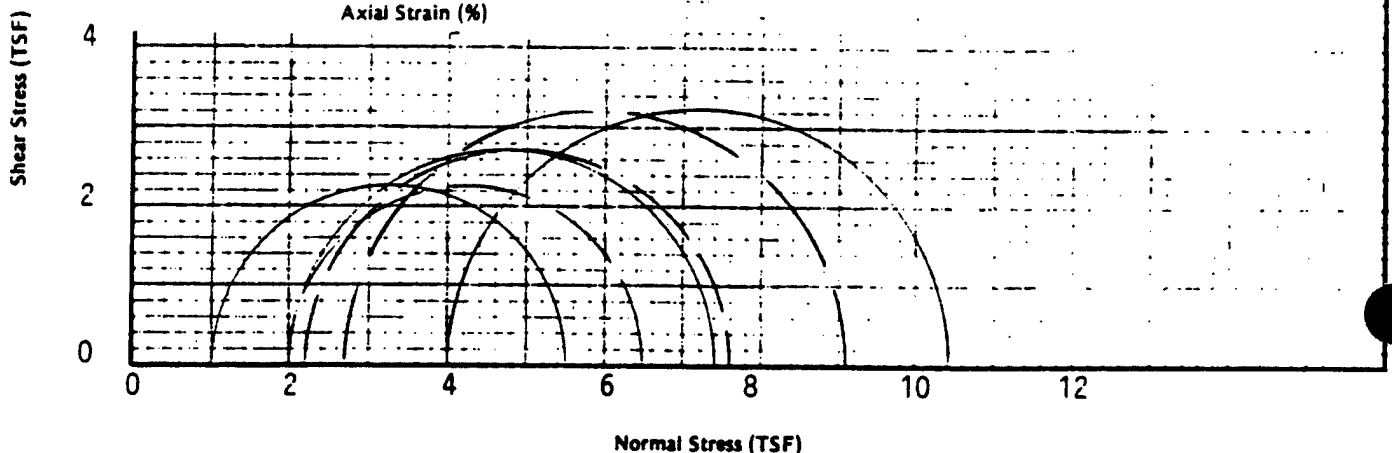
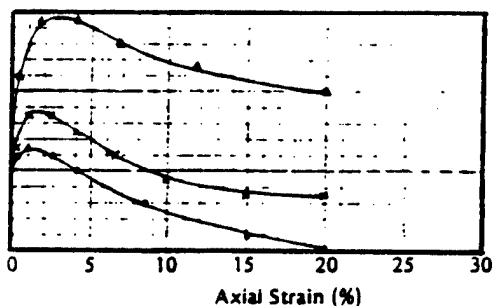
Soil Type Lean Clay (CL)

Type of Test C-U w/pp

Remarks: Specimens trimmed to given sizes; radial (spiral) drainage strips applied; saturated for 30-36 days under low confinement; back pressure and effective confining pressures increased in stages, to values shown; then maintained for 21-27 days; stressed under constant strain rates of 0.006"/min; mohr circles at maximum stress ratio.

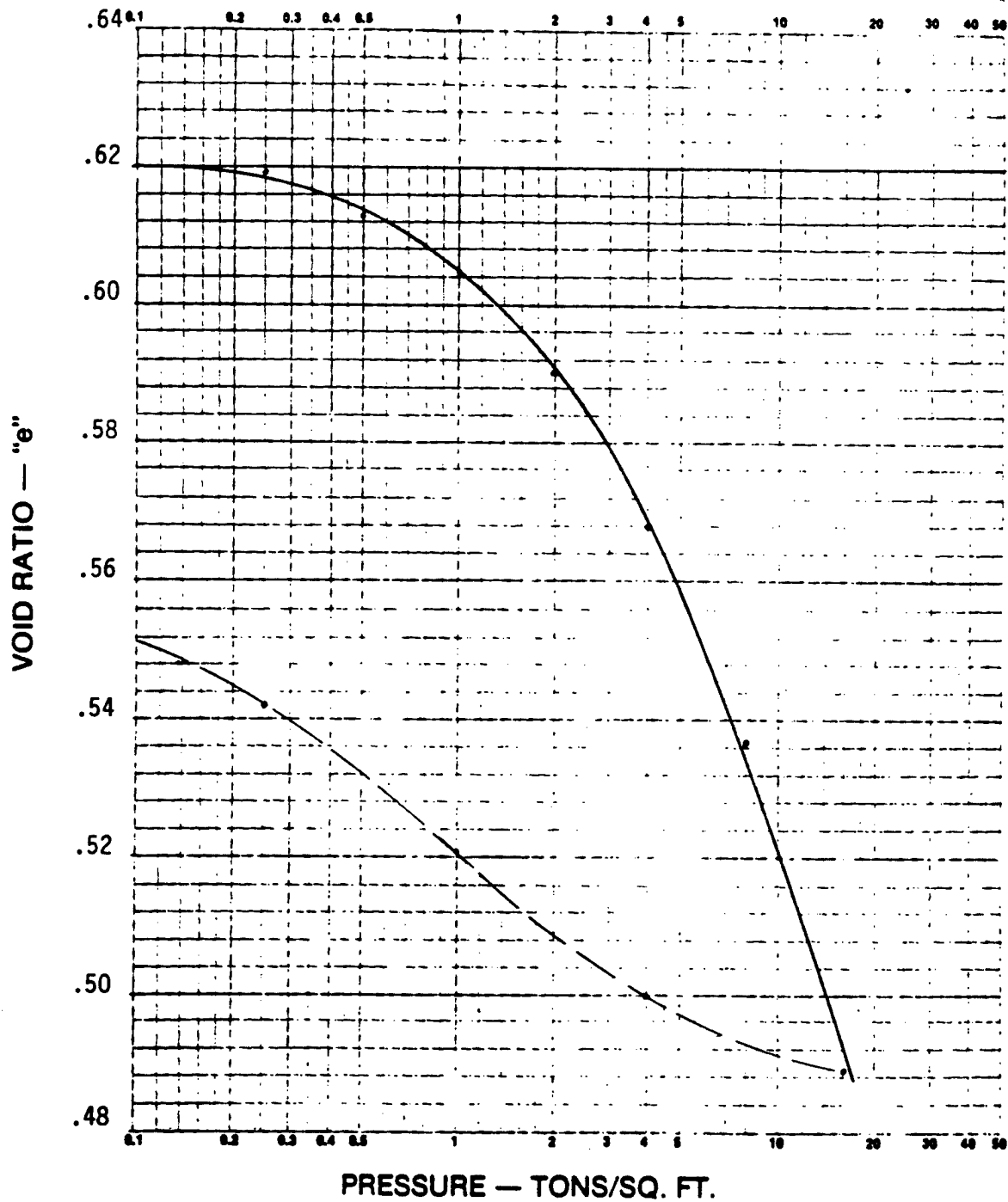


SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.41	1.41	1.41	
	Height (inches)	3.03	3.04	3.02	
	Moisture Content (%)	22.9	24.3	25.6	
	Dry Density (PCF)	101.1	99.7	98.1	
	Saturation (%)	93.7	95.8	97.3	
	Void Ratio	.65	.68	.71	
Before Shear	Moisture Content (%)	23.3	23.2	23.4	
	Dry Density (PCF)	102.7	103.0	102.7	
	Saturation (%)	98.4	99.6	99.5	
	Void Ratio	.63	.62	.63	
	Back Pressure (TSF)	6.12	6.12	6.12	
Minor Principal Stress TSF		1.00	2.00	4.00	
Maximum Deviator Stress TSF		4.46	5.48	6.42	
Ultimate Deviator Stress TSF		4.5	4.8	6.2	
LL	PI				
PL	G <sub>s</sub> 2.68				



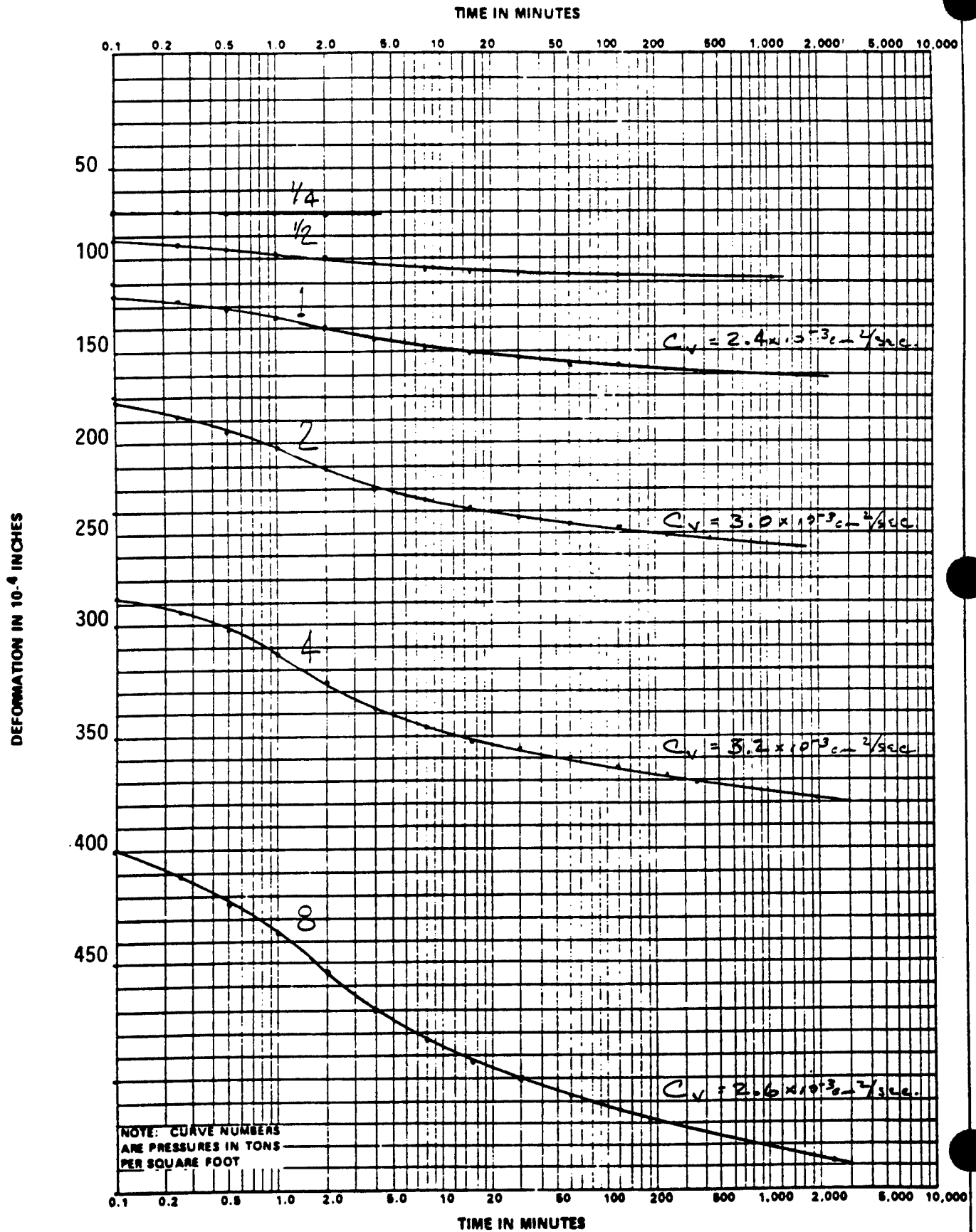
# CONSOLIDATION TEST CURVE

VOID RATIO VS. PRESSURE



Project <u>CHASKA CREEK DIVERSION</u>		Gs = 2.68		Date <u>May 18, 1988</u>
Job No. <u>4220 88-226</u>		Soil Type (ASTM: D2487) <u>Lean clay (CL)</u>		
Boring No. <u>87-75M</u>		Original Moisture Content, Dry Density <u>24.1</u> % <u>103.1</u> PCF		
Sample No. <u>2</u>		Liquid Limit <u>40.8</u> % Plastic Limit <u>15.2</u> %		
Depth (FT.) <u>33-35</u>		Preconsolidation Pressure (Pc) <u>1.9</u> TSF		
Initial Sample Height (IN.) <u>0.798</u>		Compression & Recompression Index: Cc <u>0.11</u> Cr <u>0.02</u>		
Sample Diameter (IN.) <u>2.501</u>				

# CONSOLIDATION TEST TIME CURVES



PROJECT: CHASKA CREEK DIVERSION

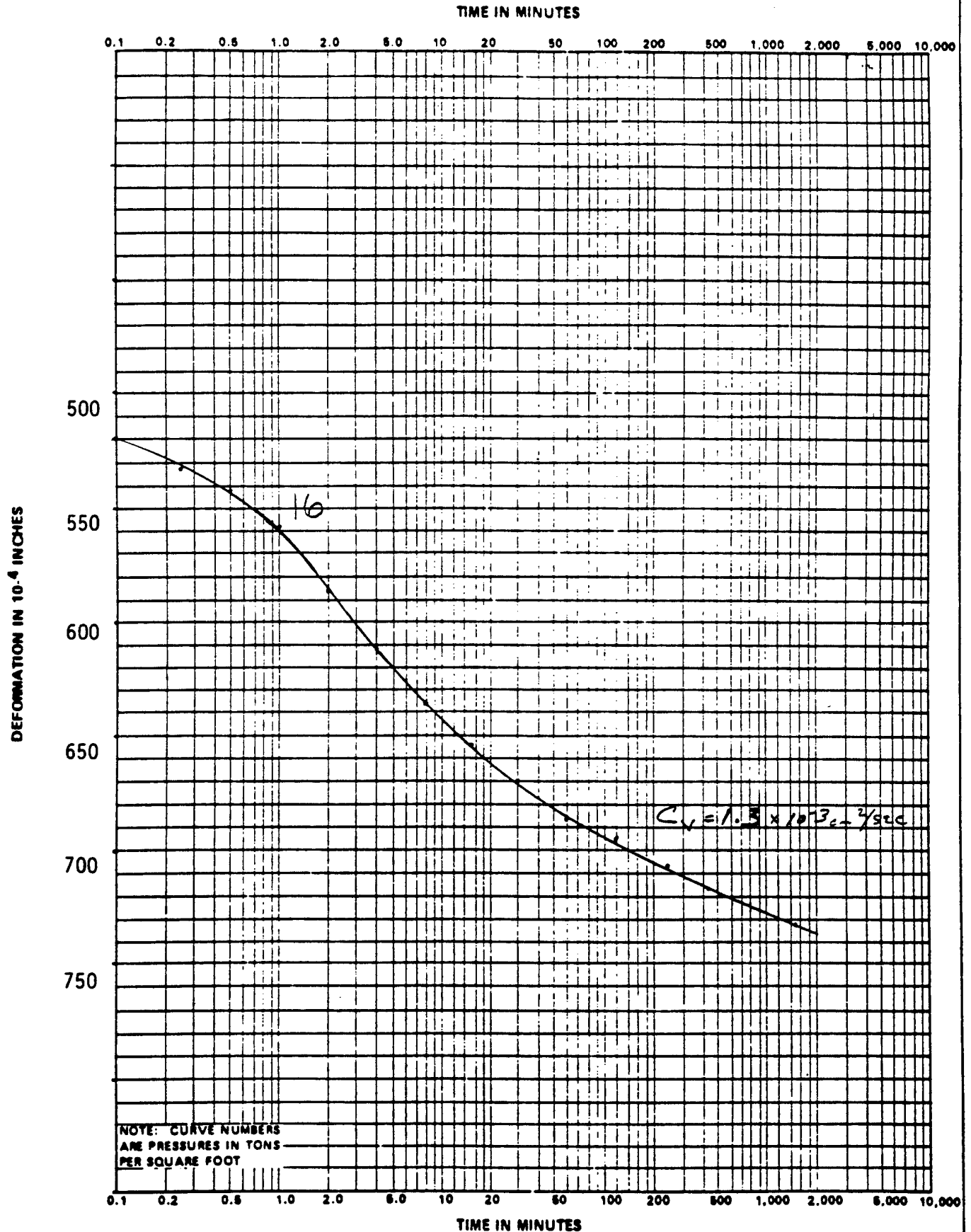
JOB NO.: 4220 88-226

SAMPLE NO.: 2

BORING NO.: 87-75M

DEPTH: 33'-35'

# CONSOLIDATION TEST TIME CURVES



PROJECT: CHASKA CREEK DIVERSION

JOB NO.: 4220 88-226

SAMPLE NO.: 2

BORING NO.: 87-75M

DEPTH: 33'-35'

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT CHASKA CREEK DIVERSION

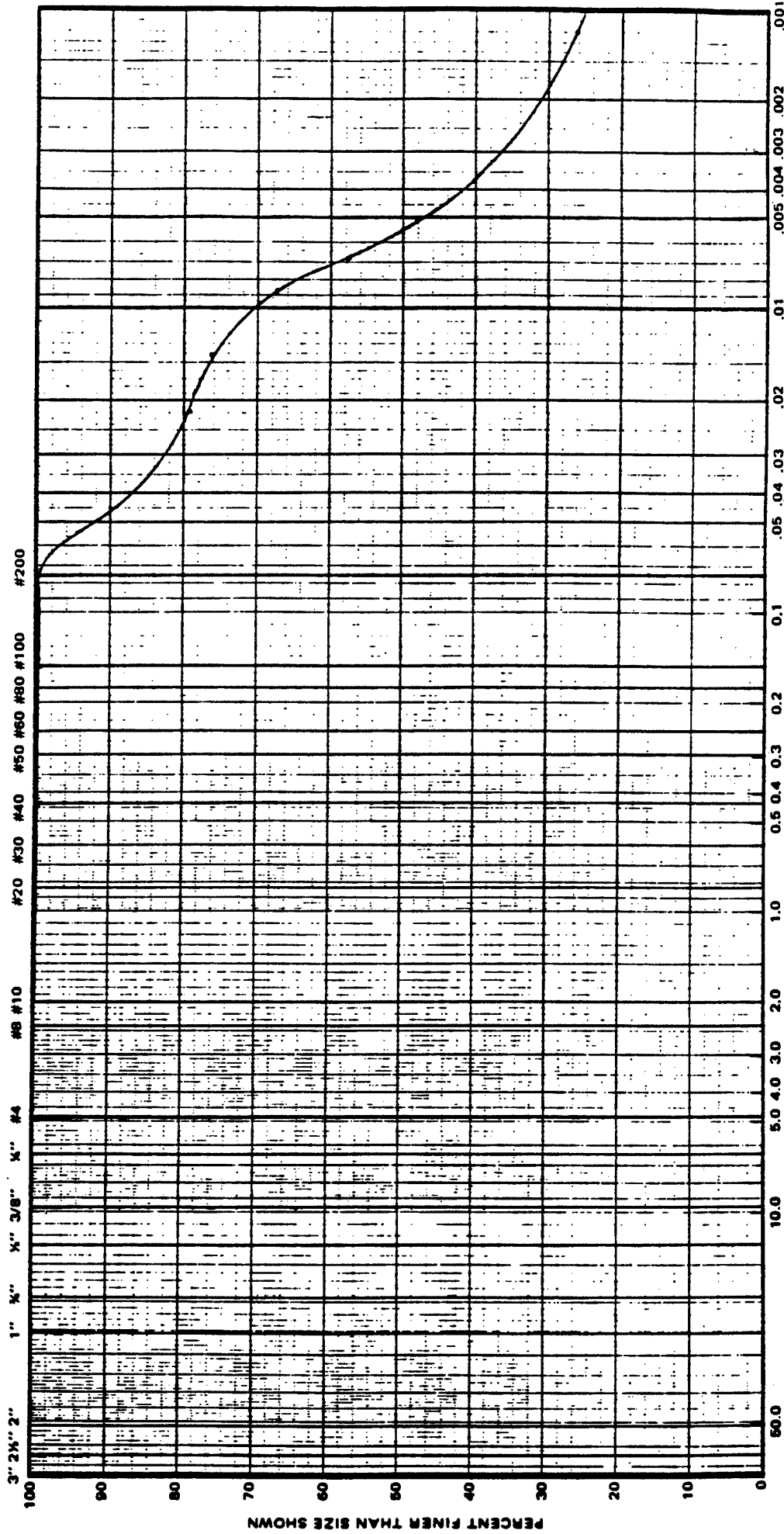
DATE May 18, 1988

REPORTED TO ST PAUL DISTRICT CORPS OF ENGINEERS

JOB NO. 4220 88-226

BORING NO. 87-75M SAMPLE NO. 2 DEPTH (FT) 33-35 SOIL TYPE Lean clay (CL)

U.S. STANDARD SIEVE SIZES



PARTICLE SIZE IN MILLIMETERS

GRAVEL SAND FINE

COARSE MEDIUM FINE

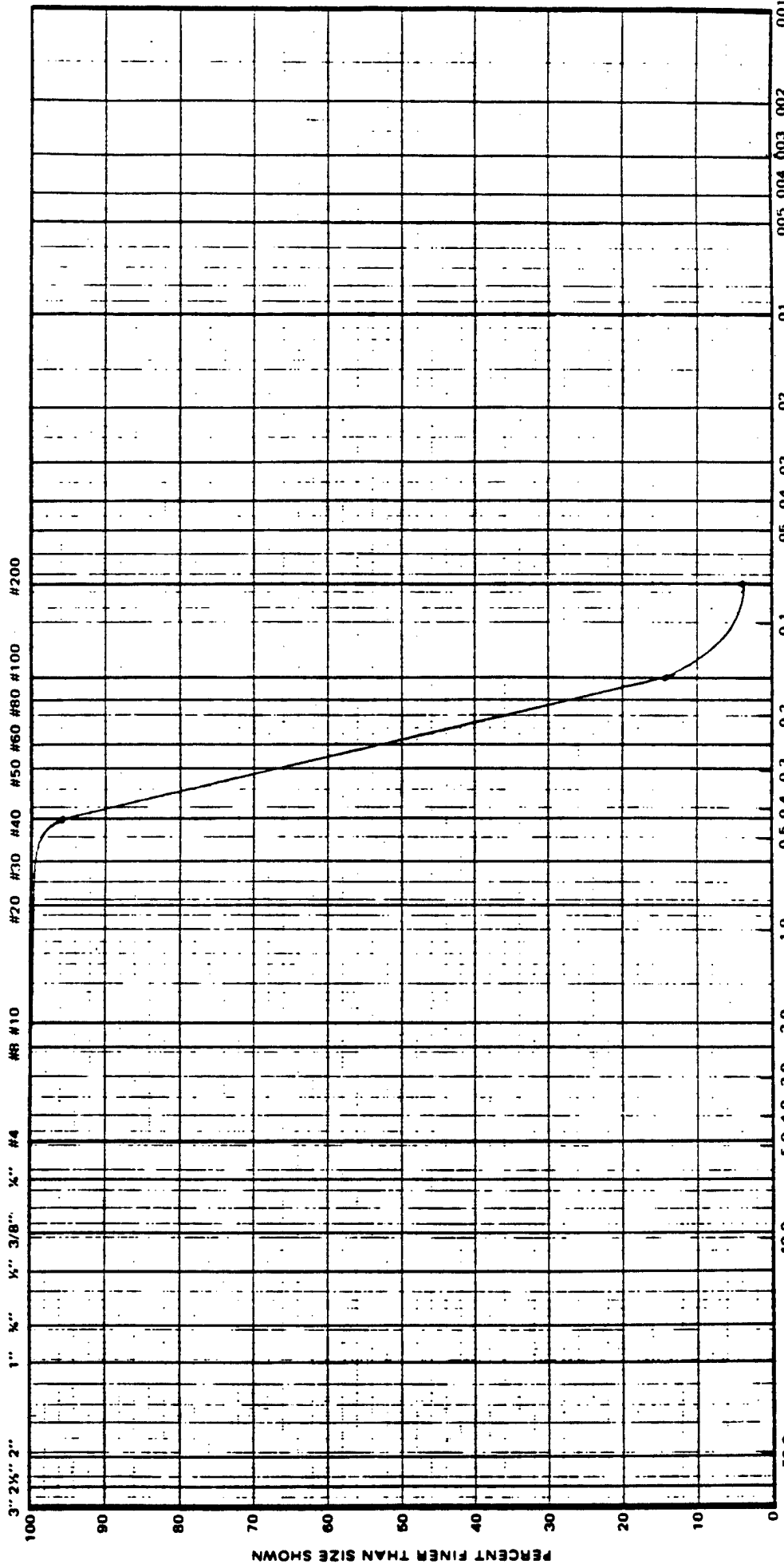
FINES



# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-75M SAMPLE NO. 3 DEPTH (FT) 10.2-10.7 SOIL TYPE Sand, Fine Grained (SP)

U.S. STANDARD SIEVE SIZES



PARTICLE SIZE IN MILLIMETERS

FINES

SAND

GRAVEL

COARSE

FINE

COARSE

MEDIUM

FINE



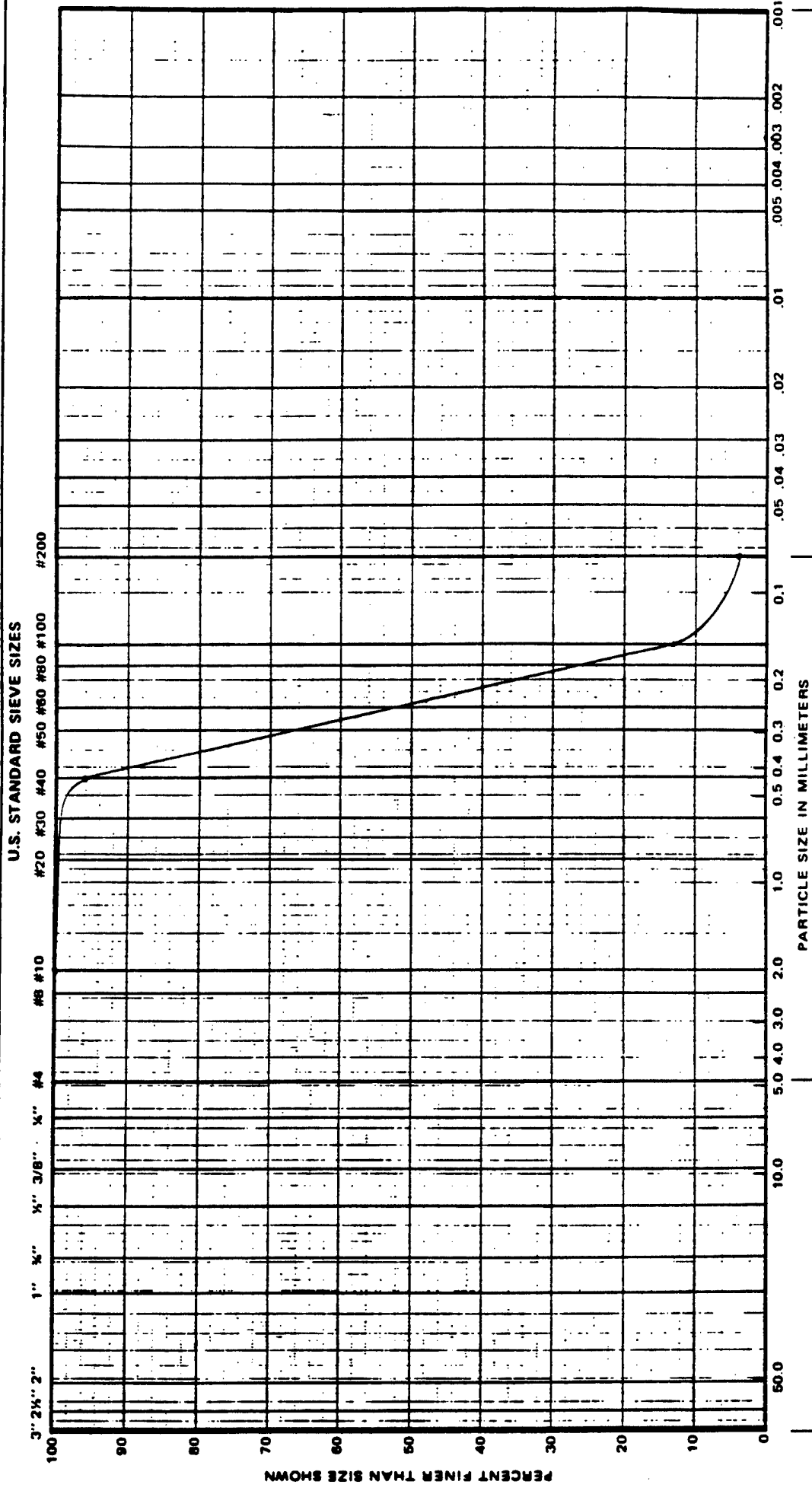
662 CROMWELL AVENUE

TWIN CITY TESTING CORPORATION

ST. PAUL, MN. 55114

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-75M SAMPLE NO. 5 DEPTH (FT) 20.4-20.9 SOIL TYPE Sand, Fine Grained (SP)



## INDEX TESTS

PROJECT: CHASKA CREEK DIVERSION

DATE: May 26, 1988

REPORTED TO: ST PAUL DISTRICT CORPS OF ENGINEERS

JOB NO.: 4220 88-226

Boring No. 87-75M

SAMPLE NO.	DEPTH (ft)	SYMBOL	WATER CONTENT (%)	ATTERBURG LIMITS		
				Liquid Limit	Plastic Limit	Plasticity Index
6	25.4 - 25.9		24.2	34.0	18.7	15.3
7	30.3 - 30.8		25.0	35.6	20.2	15.3
8	35.1 - 35.6	(CL)	24.2	40.3	18.9	21.4
9	41.2 - 41.7		24.9	50.5	24.5	26.0



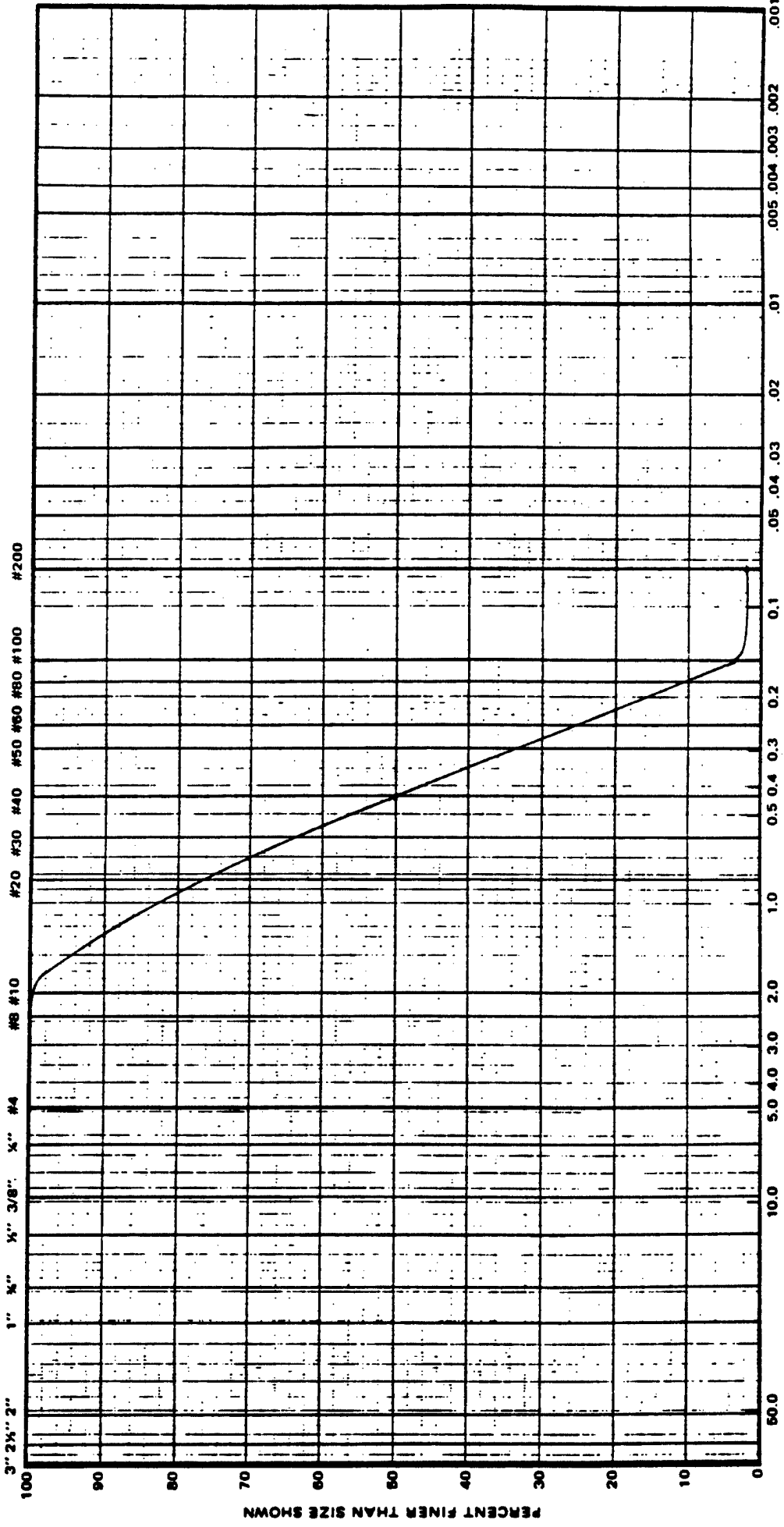
# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988

REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226

BORING NO. 87-76M SAMPLE NO. 2 DEPTH (FT) 5.3-5.8 SOIL TYPE Sand, Medium to Fine Grained (SP)

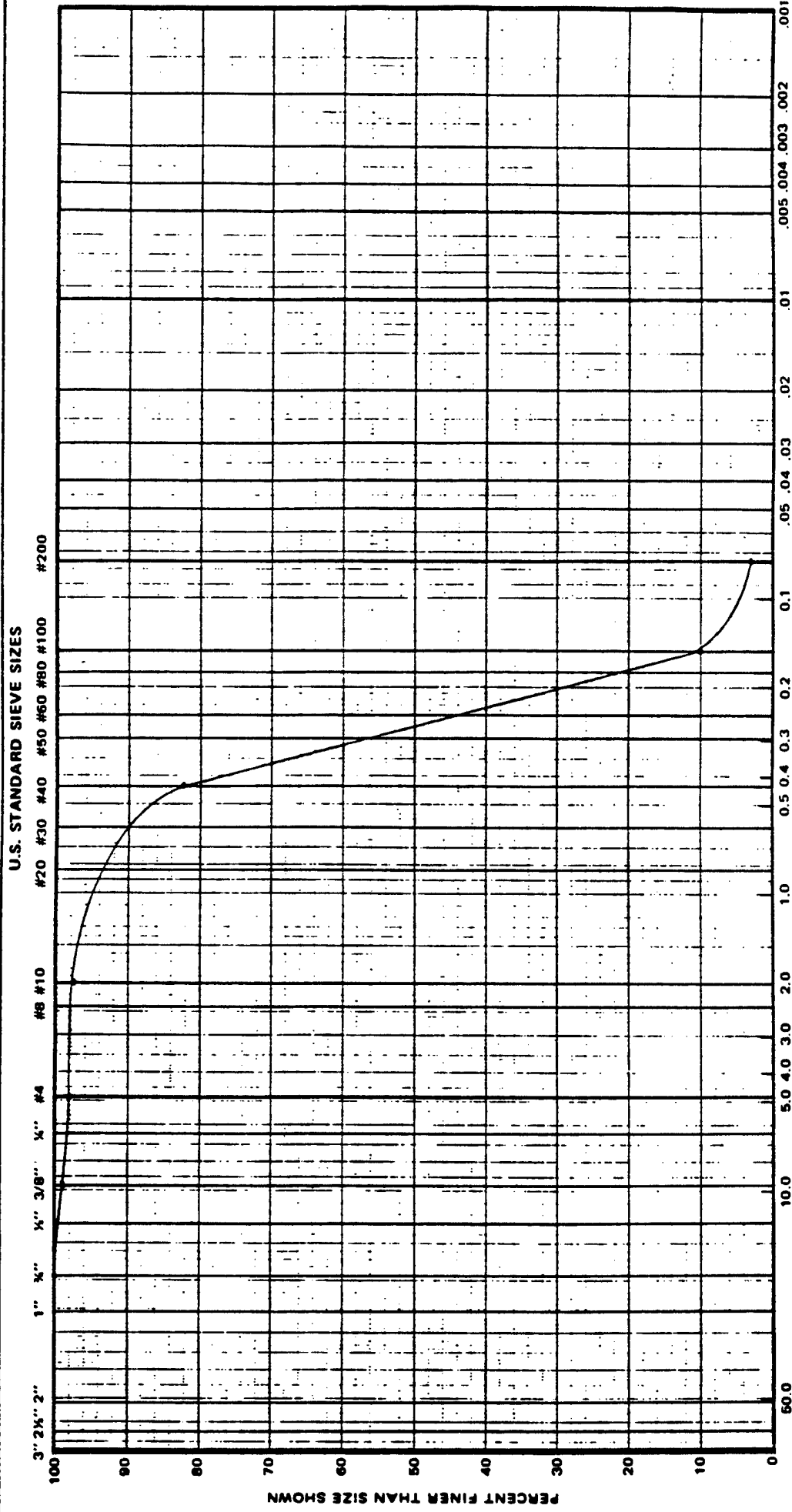
U.S. STANDARD SIEVE SIZES



GRAVEL			SAND			FINES		
COARSE	FINE		COARSE	MEDIUM	FINE			

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-76M SAMPLE NO. 3 DEPTH (FT) 11.2-11.7 SOIL TYPE Sand W/A Little Gravel, Fine Grained (SP)



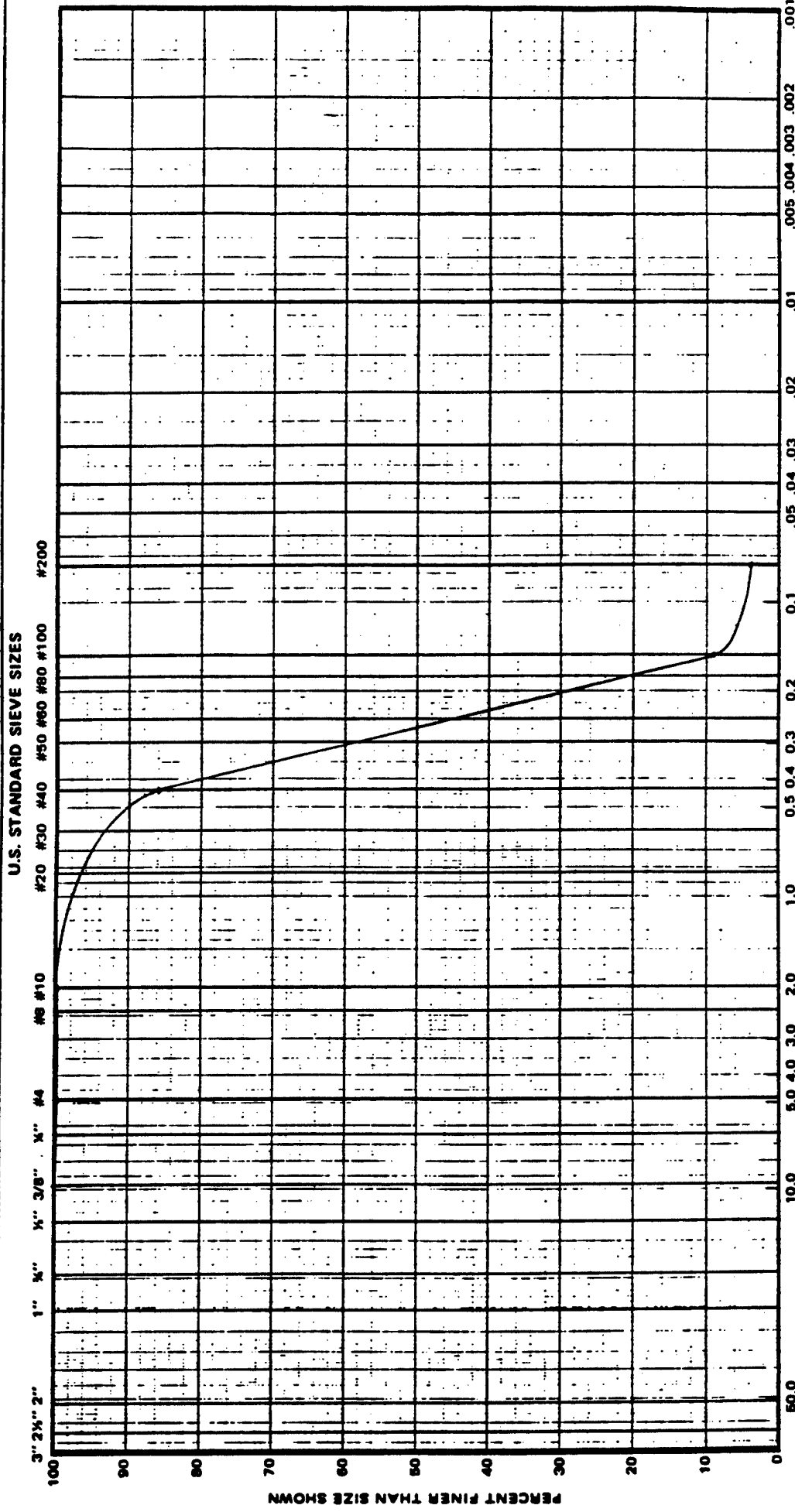
GRAVEL			SAND			FINES	
COARSE	FINE		COARSE	MEDIUM	FINE		

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988

REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226

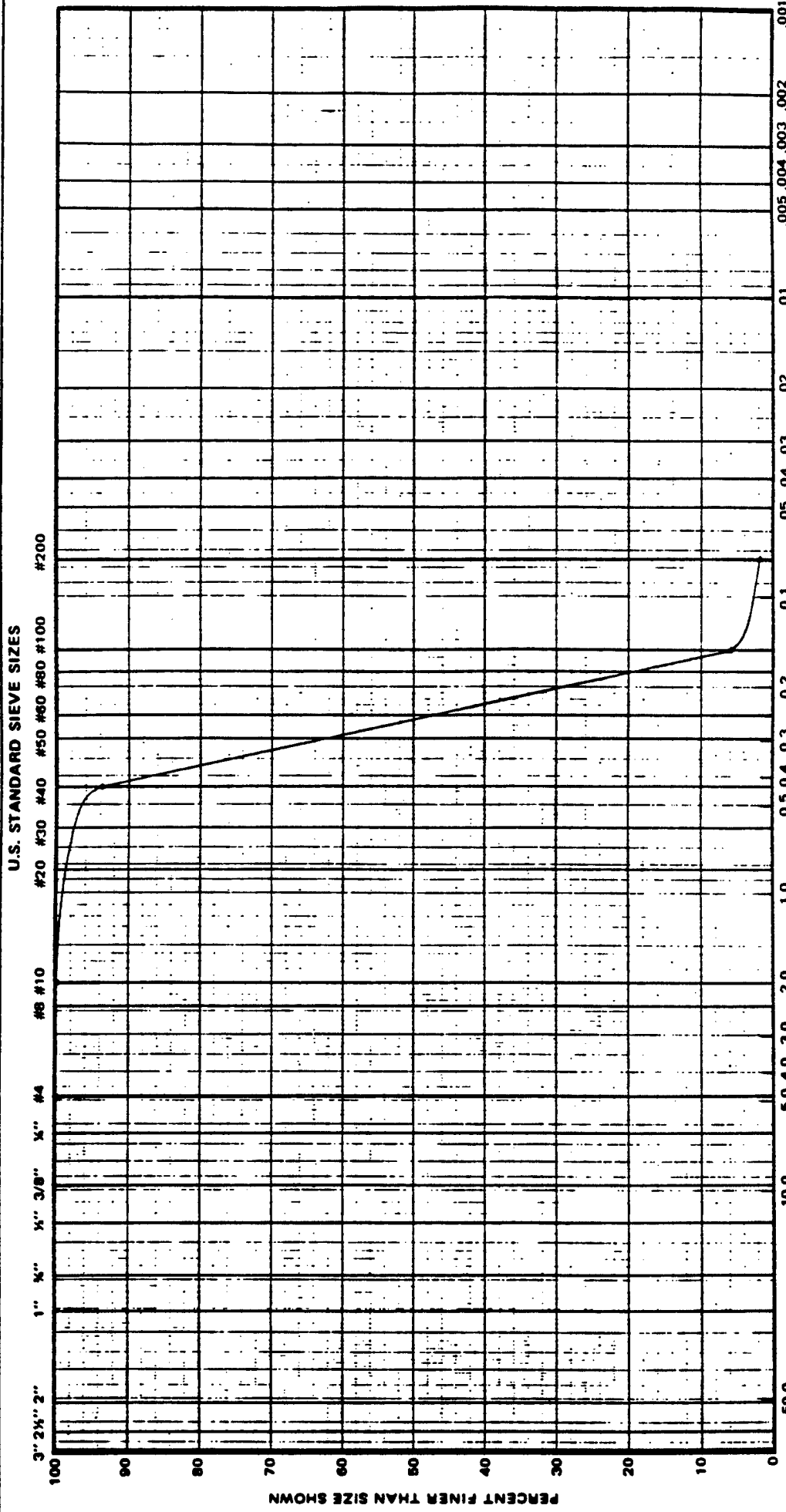
BORING NO. 87-76M SAMPLE NO. 4 DEPTH (FT) 13.2-13.8 SOIL TYPE Sand, Fine Grained (SP)



GRAVEL			SAND			FINES		
COARSE	FINE		COARSE	MEDIUM	FINE			

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-76M SAMPLE NO. 5 DEPTH (FT) 18.3-18.9 SOIL TYPE Sand, Fine Grained (SP)

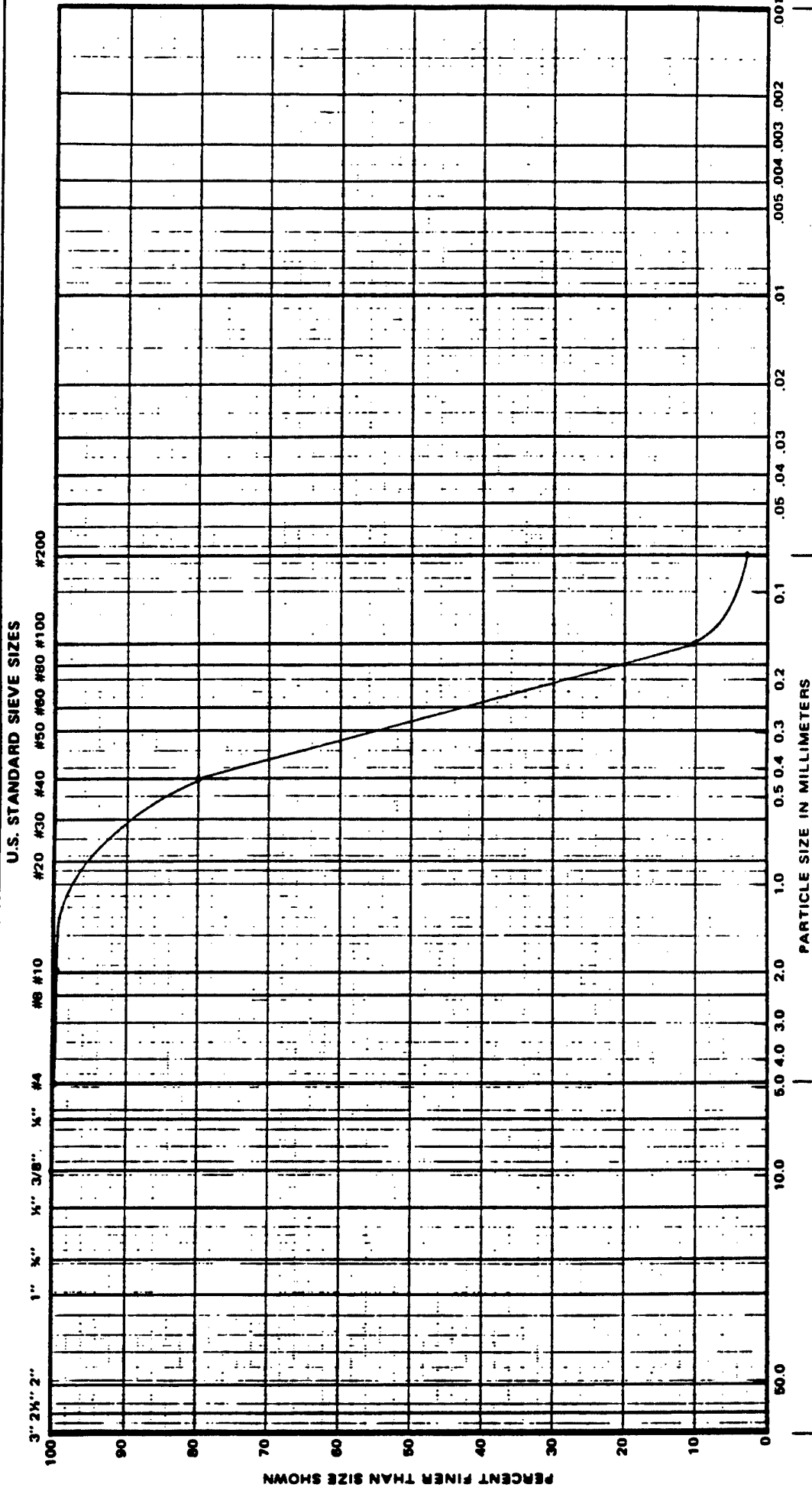


GRAVEL			SAND			FINES		
COARSE	FINE		COARSE	MEDIUM	FINE			

Figure C-203

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-76M SAMPLE NO. 6 DEPTH (FT) 21.1-21.6 SOIL TYPE Sand, Fine Grained (SP)





# TRIAXIAL TEST DATA

Date March 3, 1988

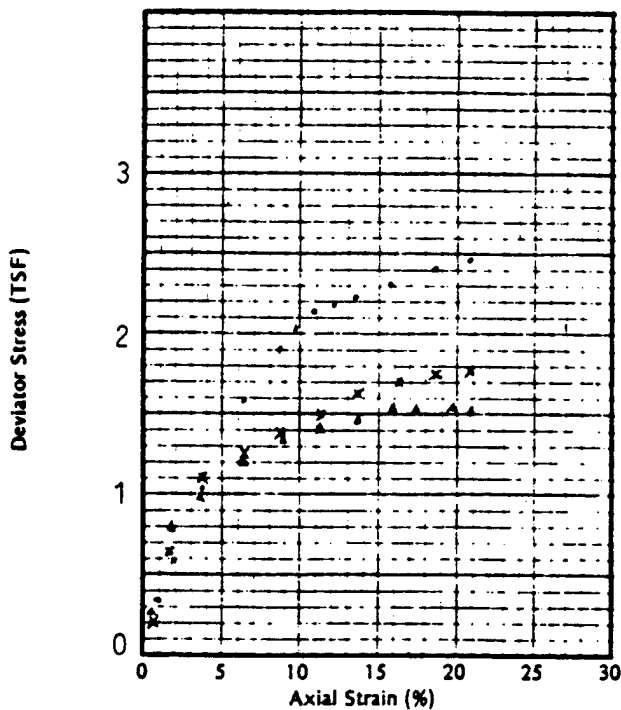
Job No. 4220 88-226

Project Chaska Creek Diversion

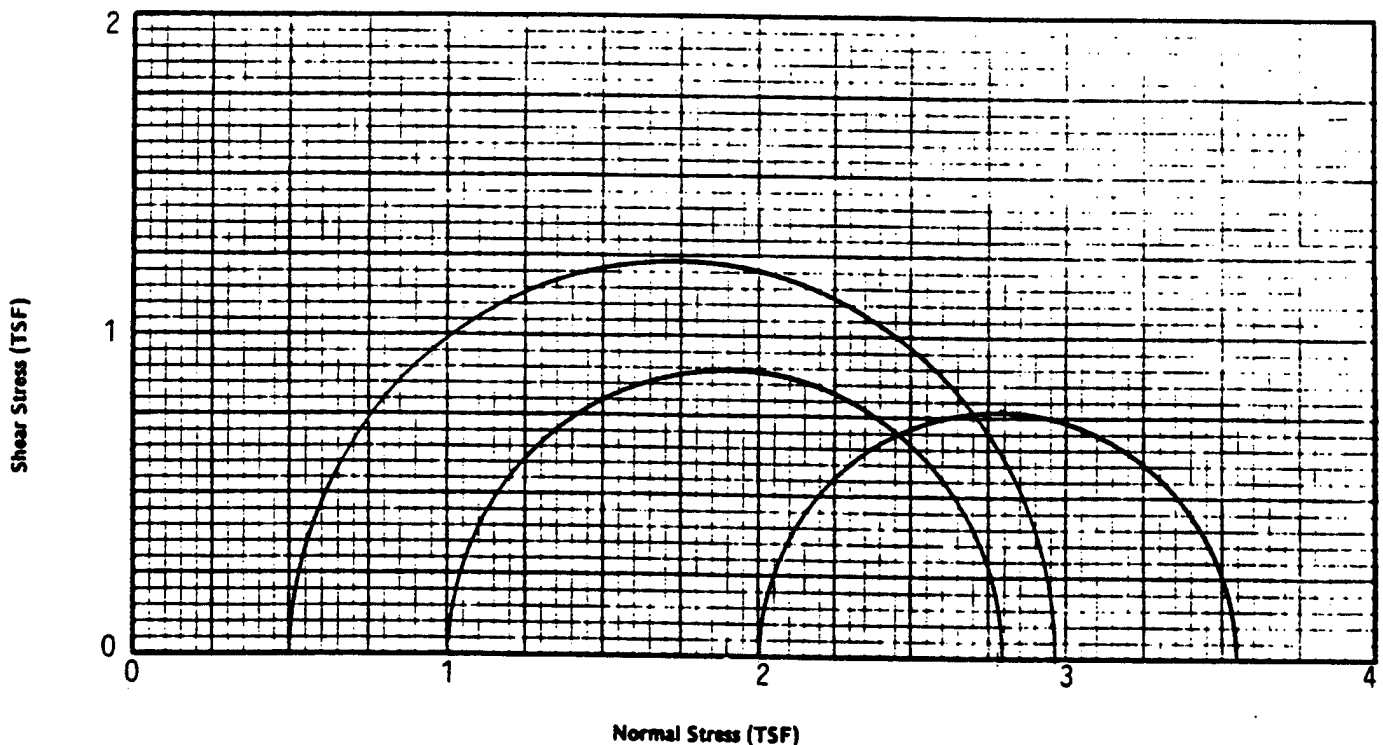
Boring No. 87-77M Sample No. 1 Depth (ft) 9.0-10.8 Type of Sample 5T

Soil Type Silt (ML) Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage valves closed; stressed to given strains at constant rate of 0.060"/min.; Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C
Initial	Diameter (inches)	1.99	1.98	1.99
	Height (inches)	4.11	4.05	4.09
	Moisture Content (%)	24.5	25.5	22.9
	Dry Density (PCF)	101.7	101.0	99.8
	Saturation (%)	100	100	91.3
	Void Ratio	0.64	0.65	0.67
Before Shear	Moisture Content (%)			
	Dry Density (PCF)			
	Saturation (%)			
	Void Ratio			
	Back Pressure (TSF)	0	0	0
Minor Principal Stress TSF $(\sigma_3)$		0.50	1.00	2.00
Maximum Deviator Stress TSF $(\sigma_1 - \sigma_3)$		2.46	1.78	1.53
Ultimate Deviator Stress TSF $(\sigma_1 - \sigma_3)$				
LL 26.4	P <sub>I</sub> 2.5			
PL 23.9	G <sub>s</sub> 2.66			



# DIRECT SHEAR TEST

PROJECT Chaska Creek Diversion

REPORTED TO St. Paul District Corps of Engineers

BORING NO. 87-77M SAMPLE NO. 1 DEPTH (FT.) 9.0-10.8

SAMPLE DIAMETER (INCHES) 2.500 SAMPLE HEIGHT (INCHES) 0.500

W.G. 23.0 22.6 23.6 Dry Density 105.2 106.0 103.7

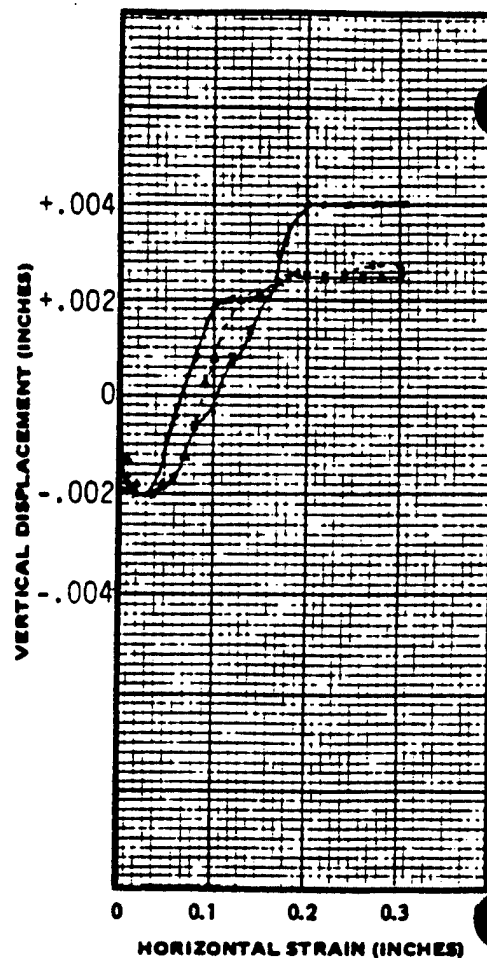
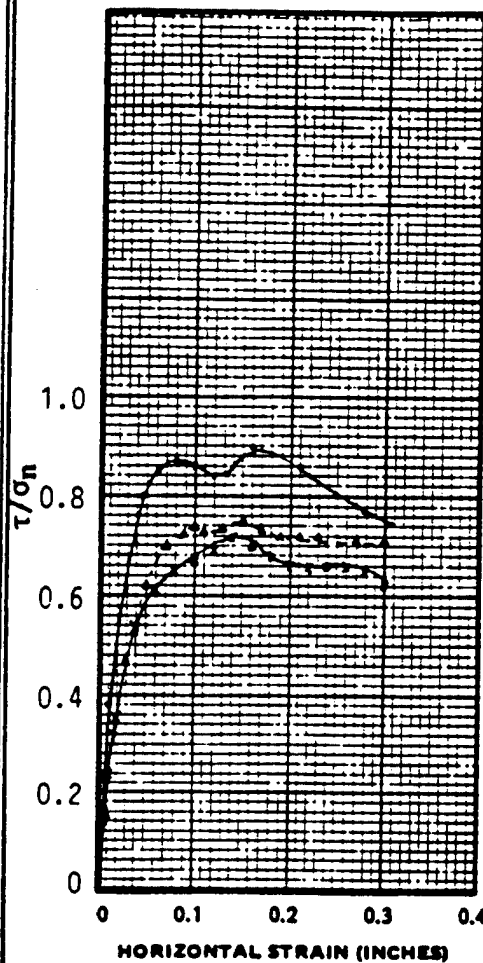
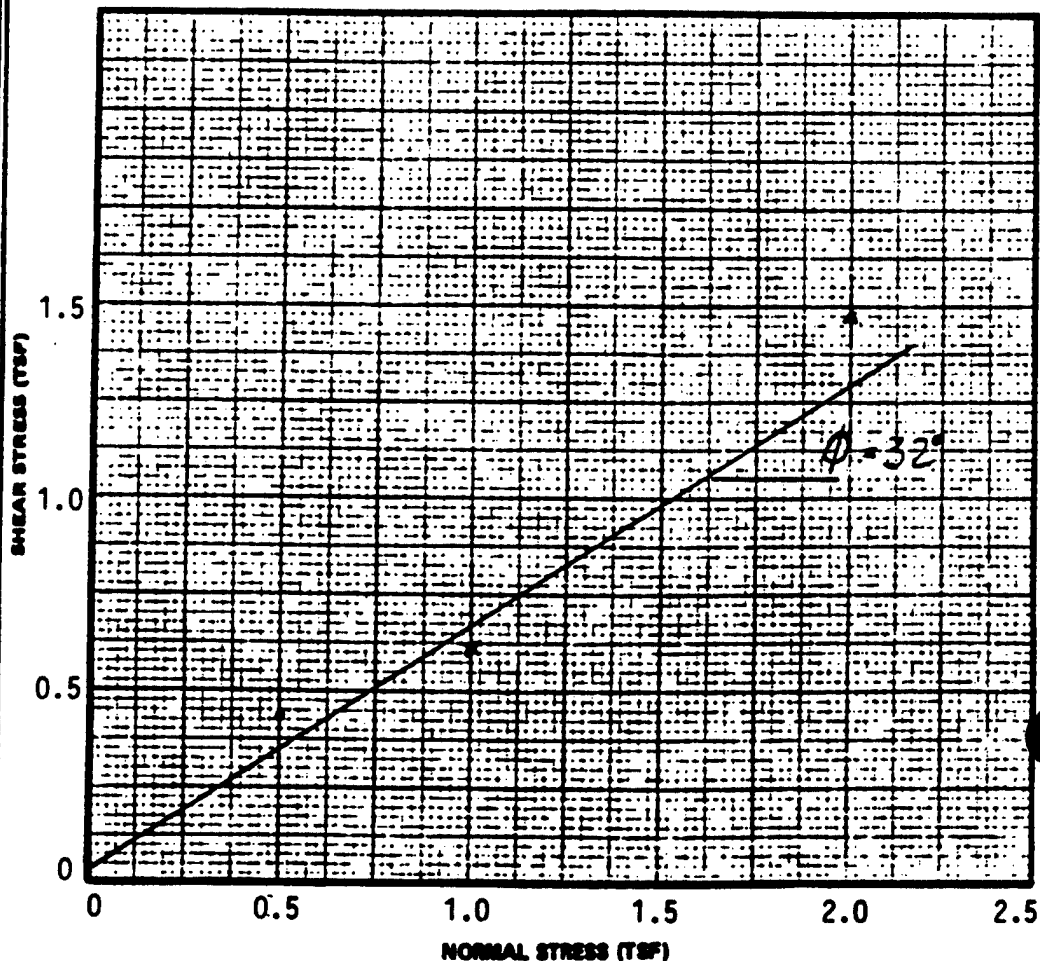
LIQUID LIMIT (%) 26.4 PLASTIC LIMIT (%) 23.9 PLASTICITY INDEX 2.5

CLASSIFICATION (ASTM: D 2487) Silt (ML)

DATE: March 4, 1988

JOB NO. 4220 88-226

NOTES: Specimens trimmed to given sizes;  
consolidated under normal load, well into secondary  
compression; sheared to given strains at constant  
rate of 0.00064"/min.



## INDEX TESTS

PROJECT Chaska Creek Diversion

DATE: March 9, 1988

REPORT St. Paul District Corps of Engineers

JOB NO: #4220 88-226

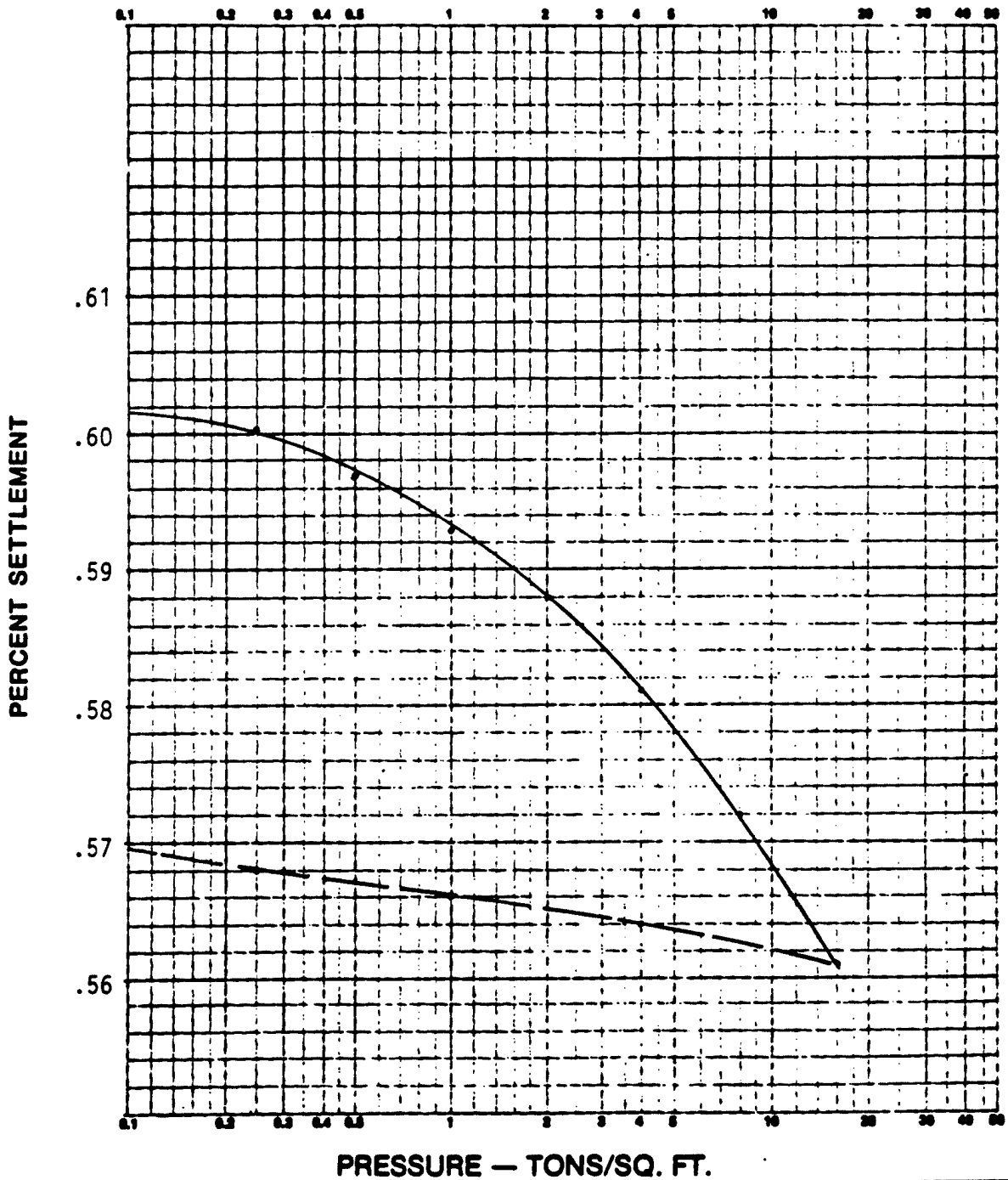
BORING 77M

SAMPLE	DEPTH (ft)	SYMBOL	WATER CONTENT (%)	ATTERBURG LIMITS		
				Liquid Limit	Plastic Limit	Plasticity Index
2	3.2-3.7	(CL)	28.1	44.8	21.8	23.0
6	16.2-16.7	(CL-ML)	30.6	25.9	22.4	3.5



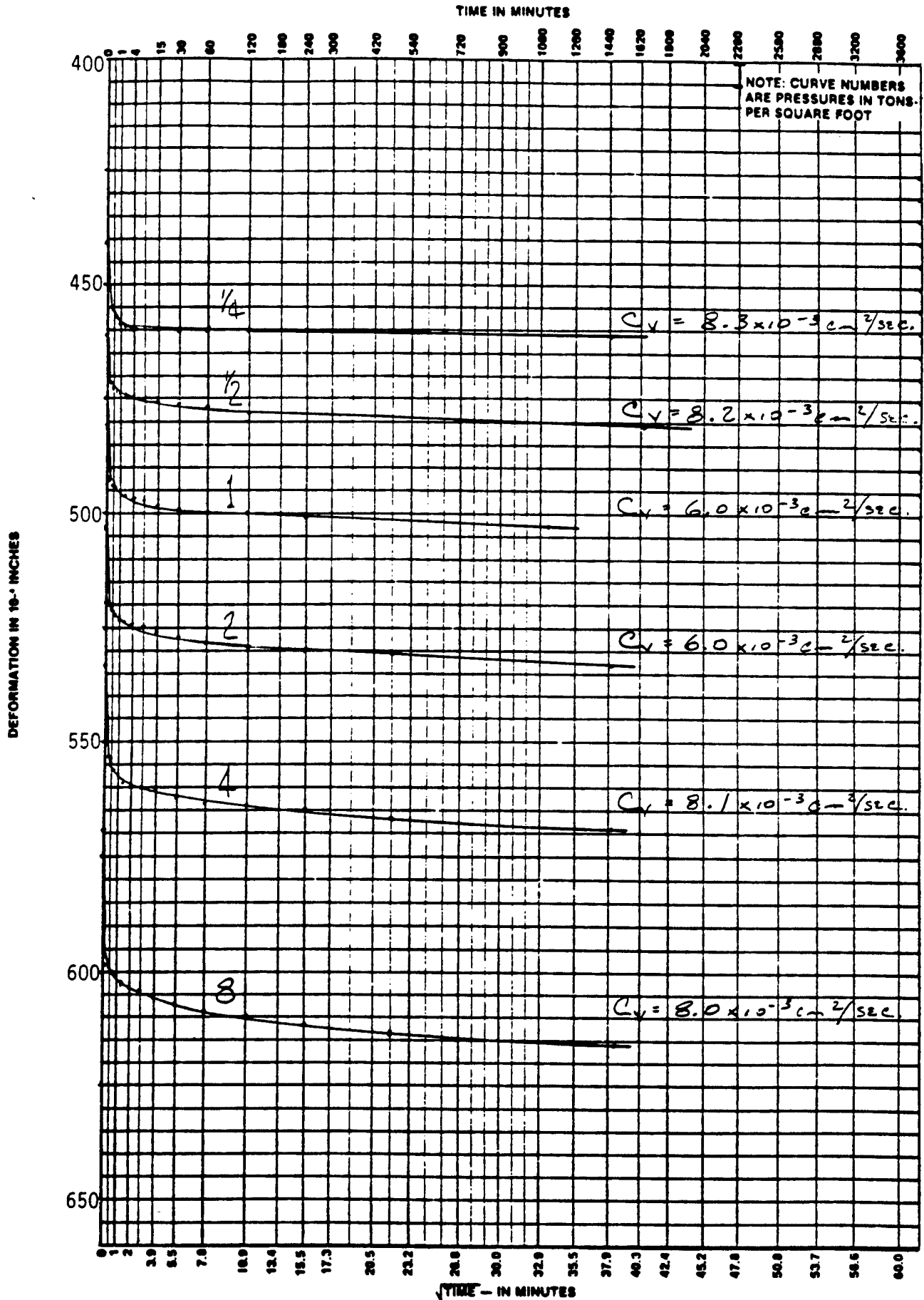
# CONSOLIDATION TEST CURVE

## PERCENT SETTLEMENT VS. PRESSURE



Project <u>Chaska Creek Diversion</u>			
Job No. <u>4220 88-226</u>	$G_s = 2.66$	Date <u>March 1, 1988</u>	
Boring No. <u>87-77M</u>	Soil Type (ASTM: D2487) <u>Silt (ML)</u>		
Sample No. <u>1</u>	Original Moisture Content, Dry Density <u>23.8</u> % <u>103.0</u> PCF		
Depth (FT.) <u>9.0-10.8 (Top)</u>	Liquid Limit <u>26.4</u> % Plastic Limit <u>23.9</u> %		
Initial Sample Height (IN.) <u>0.750</u>	Preconsolidation Pressure (Pc) <u>2.0 tsf</u>		
Sample Diameter (IN.) <u>2.500</u>	Compression & Recompression Index: $C_c$ <u>0.02</u> $C_r$ _____		

# CONSOLIDATION TEST TIME CURVES



PROJECT Chaska Creek Diversion

JOB. NO. 4220 88-226

SAMPLE NO. 1

BORING NO. 87-77M

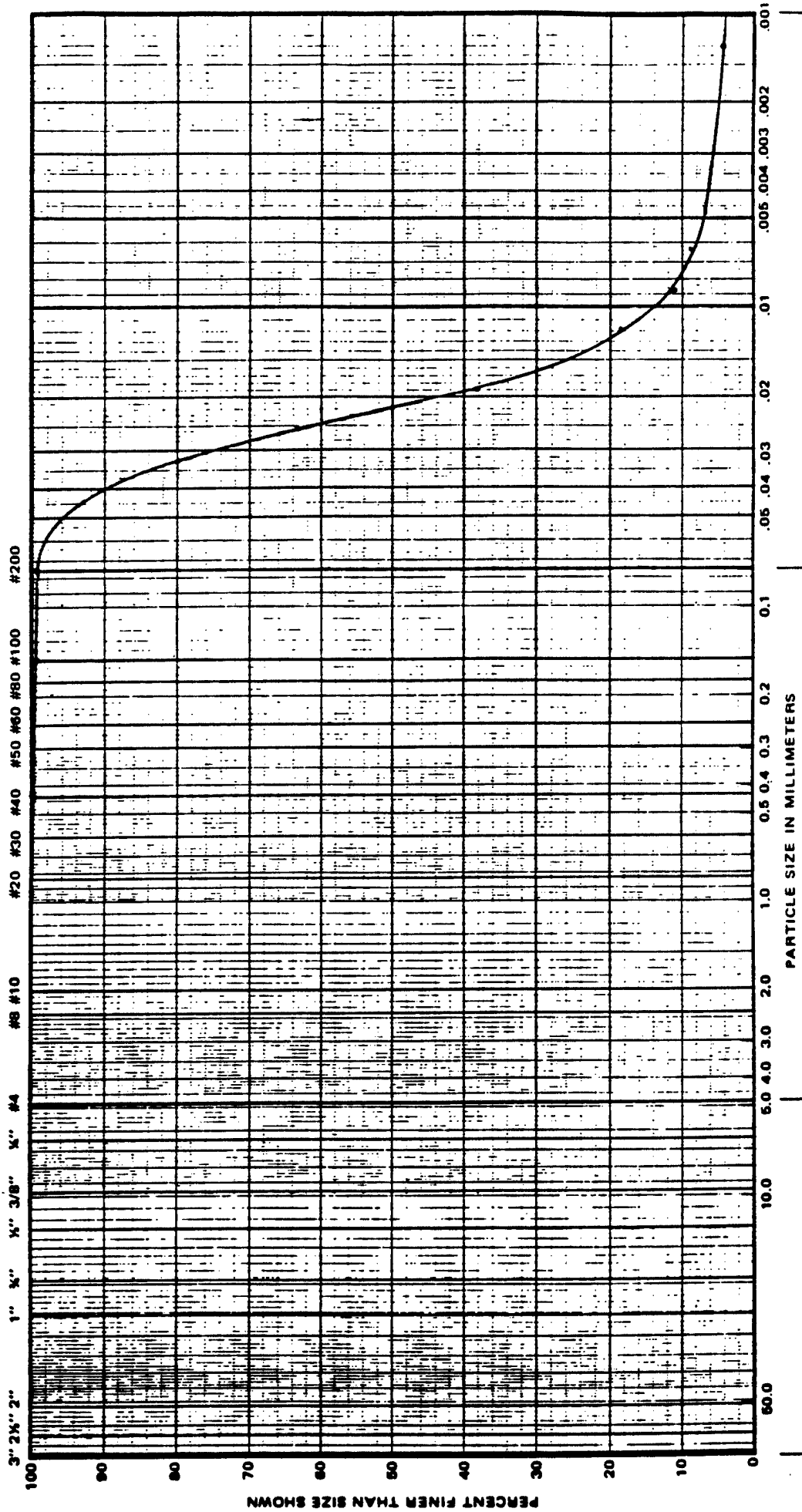
DEPTH 9.0'-10.8' (Top)

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE March 8, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226

BORING NO. 87-77M SAMPLE NO. 1 DEPTH (FT) 9.0-10.8 SOIL TYPE Silt (ML)

U.S. STANDARD SIEVE SIZES



FINES

SAND  
MEDIUM FINE

GRAVEL  
COARSE FINE

# TRIAXIAL TEST DATA

Date March 2, 1988

Job No. 4220 88-226

Project Chaska Creek Diversion

Boring No. 87-77M

Sample No. 2

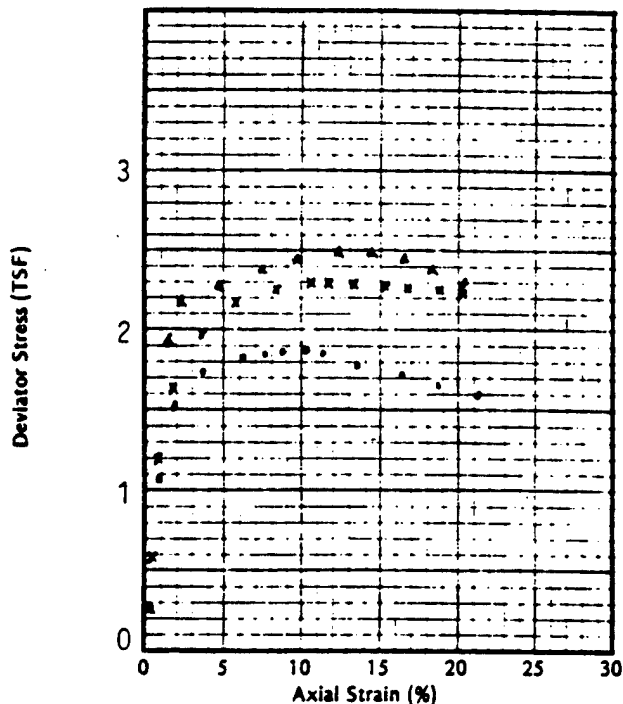
Depth (ft) 13.0-14.5

Type of Sample 5T

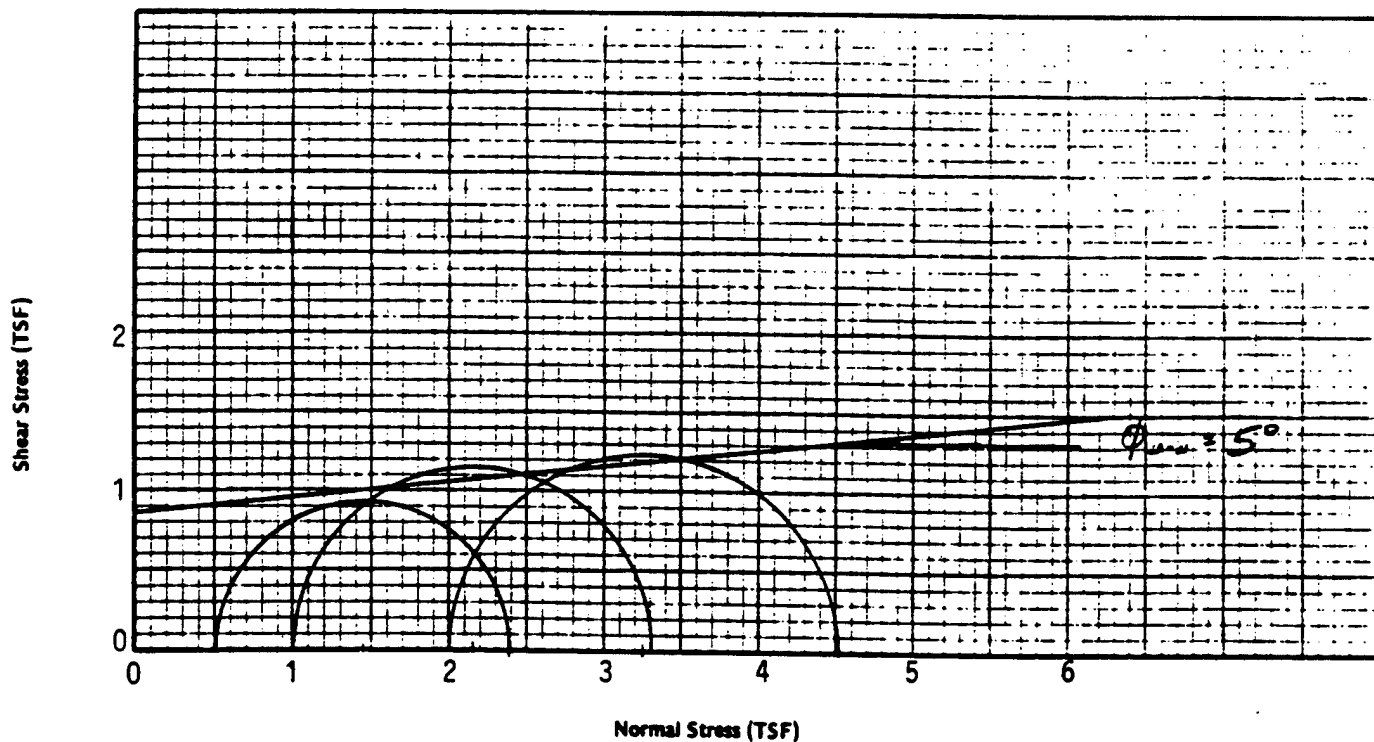
Soil Type Lean Clay (CL/CH)

Type of Test U-U

Remarks: Specimens trimmed to given sizes; lucite discs placed on each end; all drainage valves closed; stressed to given strains at constant rate of 0.060"/min.; Mohr circles at maximum deviator stress.



SPECIMEN NO.		A	B	C	
Initial	Diameter (inches)	1.99	2.00	2.00	
	Height (inches)	4.05	4.21	4.14	
	Moisture Content (%)	28.5	28.2	29.0	
	Dry Density (PCF)	95.4	96.3	95.6	
	Saturation (%)	100	100	100	
	Void Ratio	0.77	0.75	0.76	
Before Shear	Moisture Content (%)				
	Dry Density (PCF)				
	Saturation (%)				
	Void Ratio				
	Back Pressure (TSF)	0	0	0	
Minor Principal Stress TSF $(\sigma_3)$		0.50	1.00	2.00	
Maximum Deviator Stress TSF $(\sigma_1 - \sigma_3)$		1.86	2.30	2.50	
Ultimate Deviator Stress TSF $(\sigma_1 - \sigma_3)$					
LL 47.7	PI 25.6				
PL 22.1	G <sub>s</sub> 2.70				



# DIRECT SHEAR TEST

PROJECT Chaska Creek Diversion

REPORTED TO St. Paul District Corps of Engineers

BORING NO. 87-77M SAMPLE NO. 2

DEPTH (FT.) 13.0-14.5

SAMPLE DIAMETER (INCHES) 2.500 SAMPLE HEIGHT (INCHES) 0.500

W.G. 26.6 28.4 28.1 Dry Density 99.5 96.0 101.5

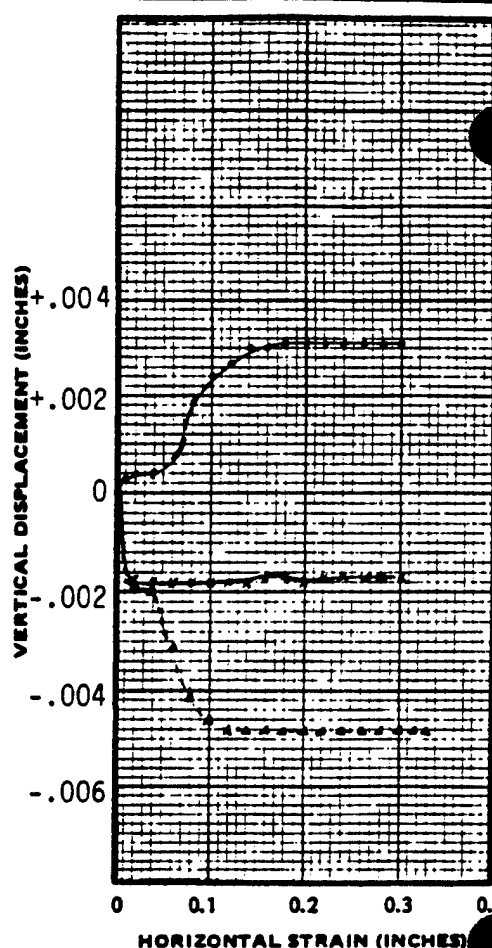
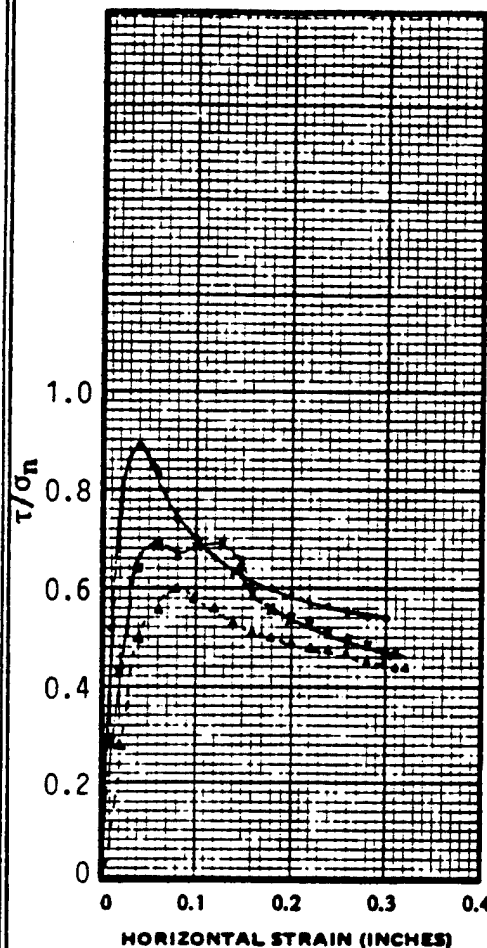
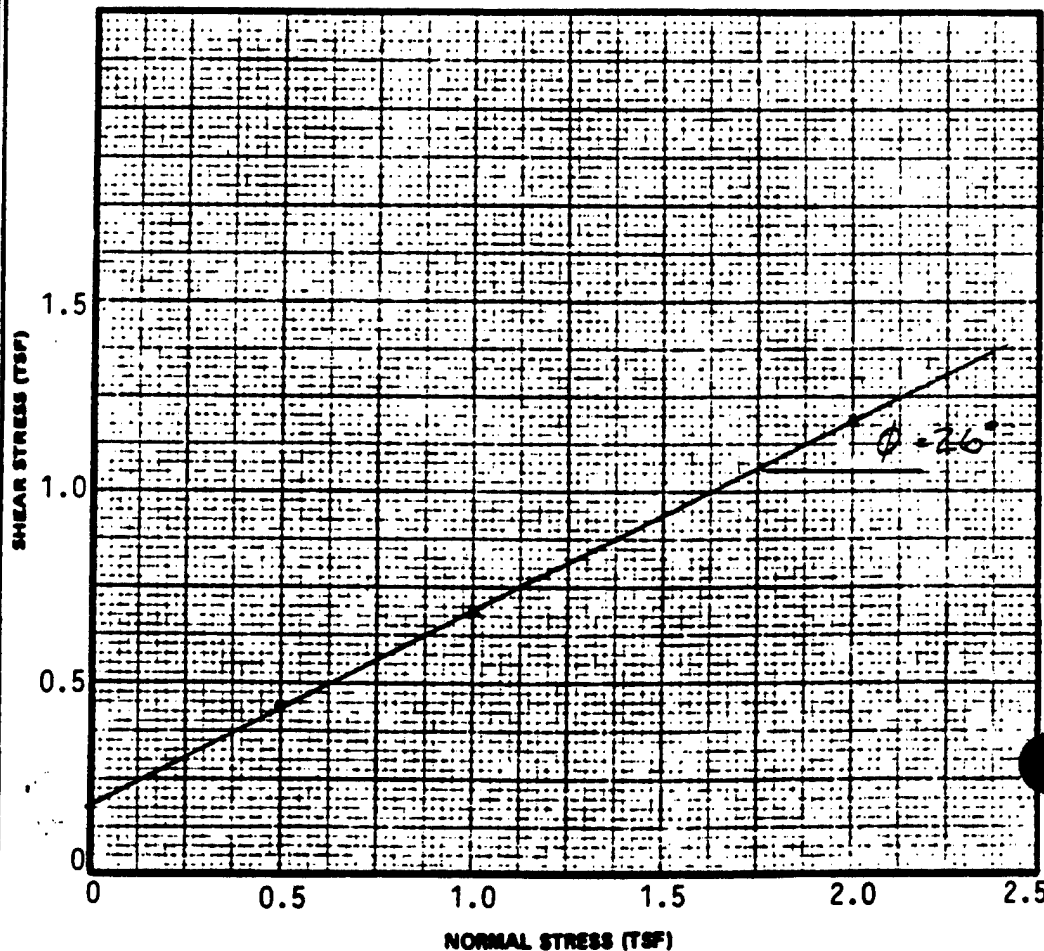
LIQUID LIMIT (%) 47.7 PLASTIC LIMIT (%) 22.1 PLASTICITY INDEX 25.6

CLASSIFICATION (ASTM: D 2487) Lean Clay (CL/CH)

DATE: March 1, 1988

JOB NO. 4220 88-226

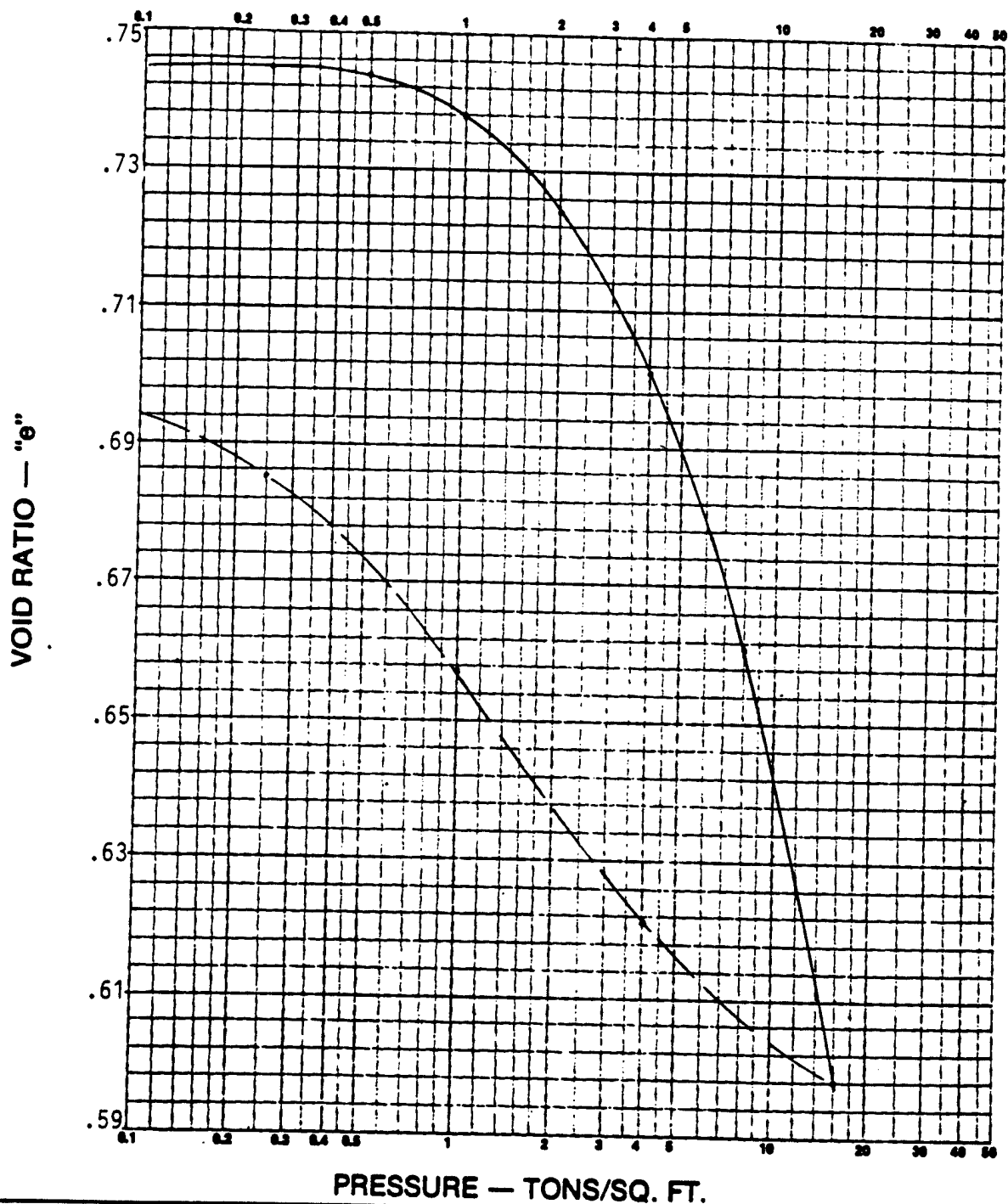
NOTES: Specimens trimmed to given sizes;  
consolidated under normal load, well into  
secondary compression; sheared to given strains at  
constant rate of 0.00064"/min.





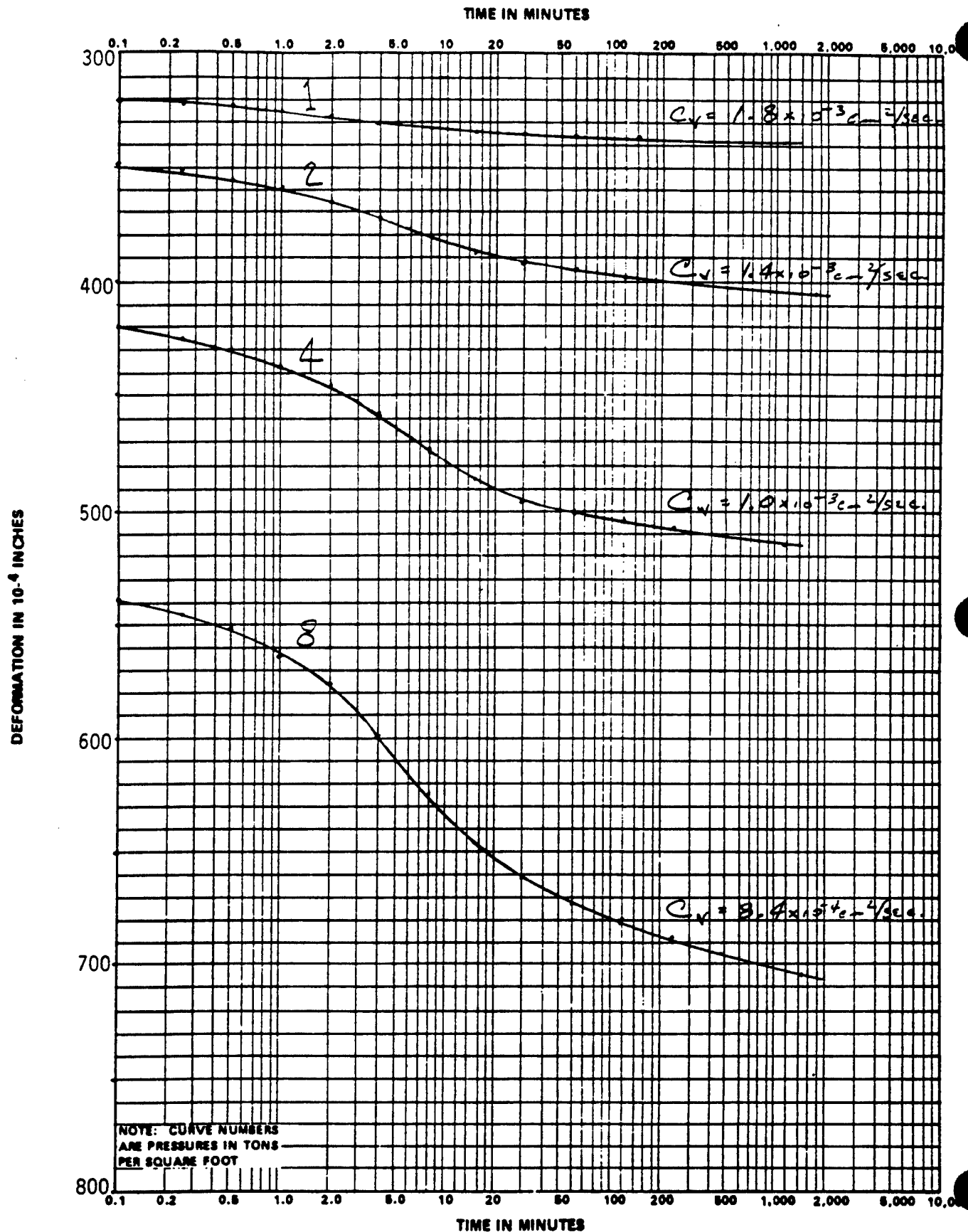
# CONSOLIDATION TEST CURVE

VOID RATIO VS. PRESSURE



Project <u>Chaska Creek Diversion</u>			
Job No. <u>4220 88-226</u>	$G_s = 2.70$	Date <u>March 1, 1988</u>	
Boring No. <u>87-77M</u>	Soil Type (ASTM: D2487) <u>Lean Clay (CL/CH)</u>		
Sample No. <u>2</u>	Original Moisture Content, Dry Density <u>28.6</u> % <u>96.7</u> PCF		
Depth (FT.) <u>13.0'-14.5' (Middle)</u>	Liquid Limit <u>47.7</u> % Plastic Limit <u>22.1</u> %		
Initial Sample Height (IN.) <u>0.795</u>	Preconsolidation Pressure (Pc) <u>2.2 tsf</u>		
Sample Diameter (IN.) <u>2.501</u>	Compression & Recompression Index: $C_c$ <u>0.14</u> $C_r$ _____		

# CONSOLIDATION TEST TIME CURVES



PROJECT: Chaska Creek Diversion

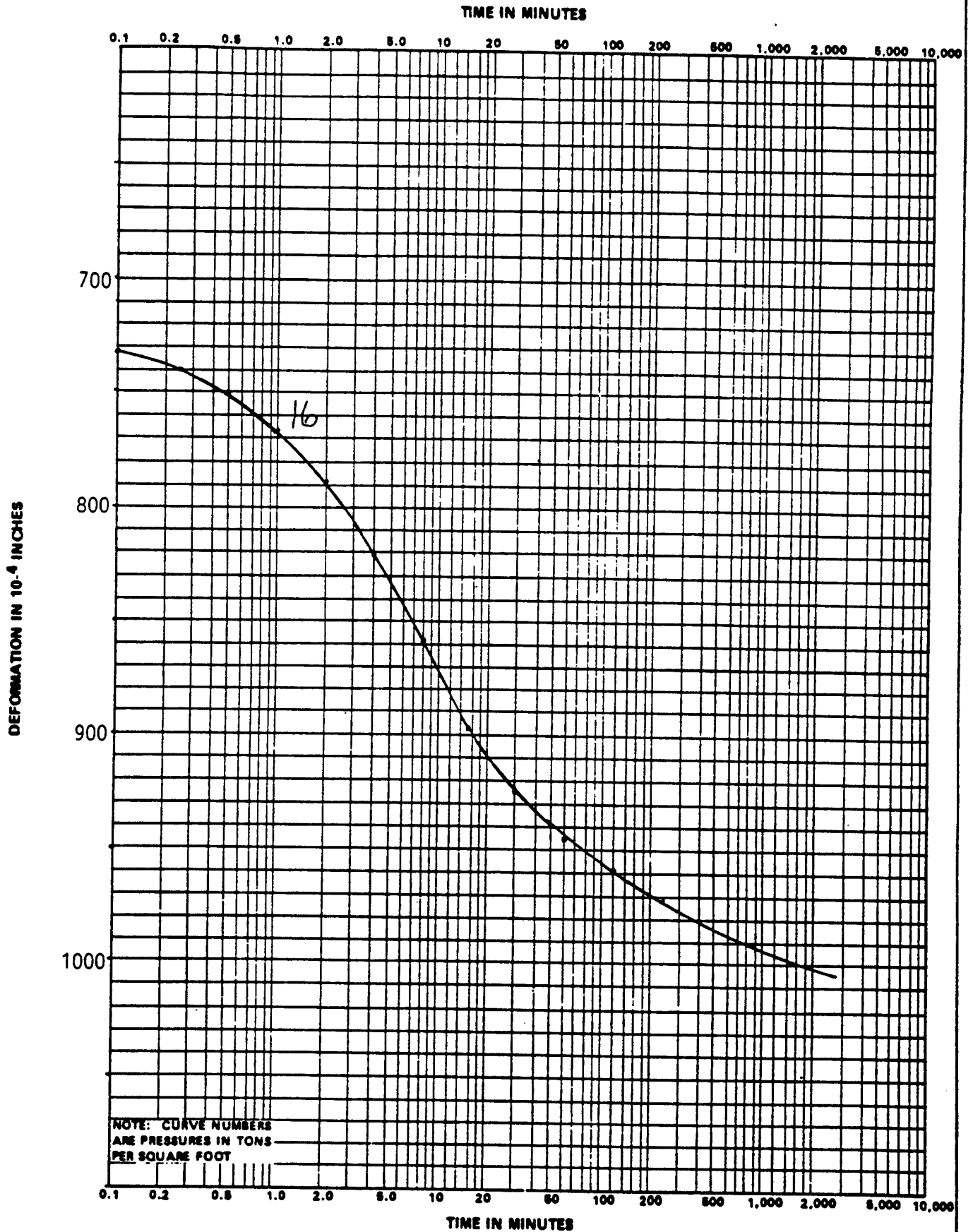
JOB NO.: 4220 88-226

SAMPLE NO.: 2

BORING NO.: 87-77M

DEPTH: 13.0'-14.5' (Middle)

# CONSOLIDATION TEST TIME CURVES



PROJECT: Chaska Creek Diversion

JOB NO.: 4220 88-226

SAMPLE NO.: 2

BORING NO.: 87-77M

DEPTH: 13.0'-14.5' (Middle)

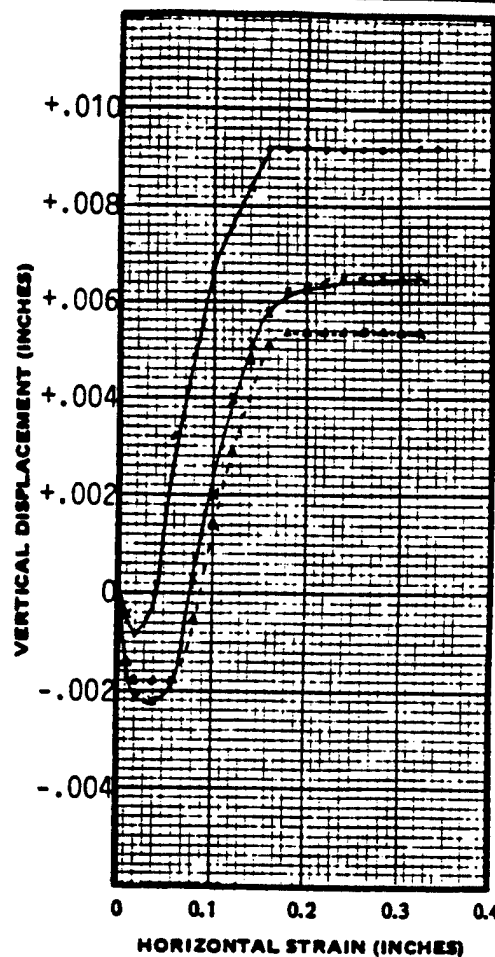
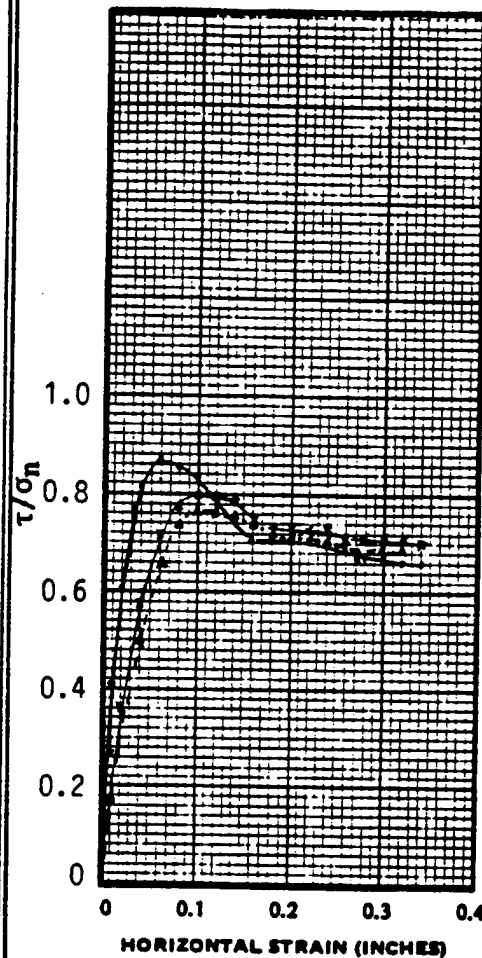
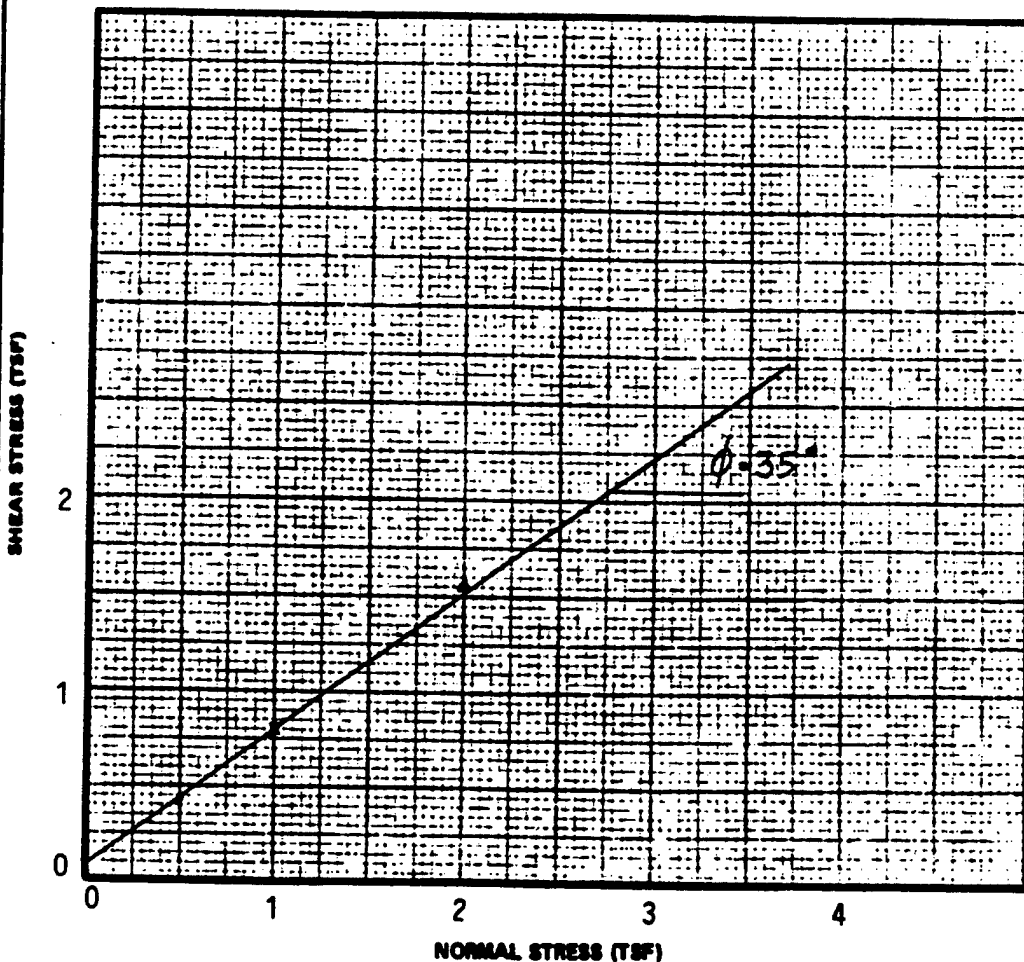


# DIRECT SHEAR TEST

PROJECT Chaska Creek Diversion  
 REPORTED TO St. Paul District Corps of Engineers  
 BORING NO. 87-77M SAMPLE NO. 3 DEPTH (FT.) 20-22  
 SAMPLE DIAMETER (INCHES) 2.500 SAMPLE HEIGHT (INCHES) 0.500  
 W.C. 21.1 20.4 21.6 Dry Density 109.0 110.7 109.0  
 LIQUID LIMIT (%) 23.2 PLASTIC LIMIT (%) 23.3 PLASTICITY INDEX NP  
 CLASSIFICATION (ASTM: D 2487) SILT (ML)

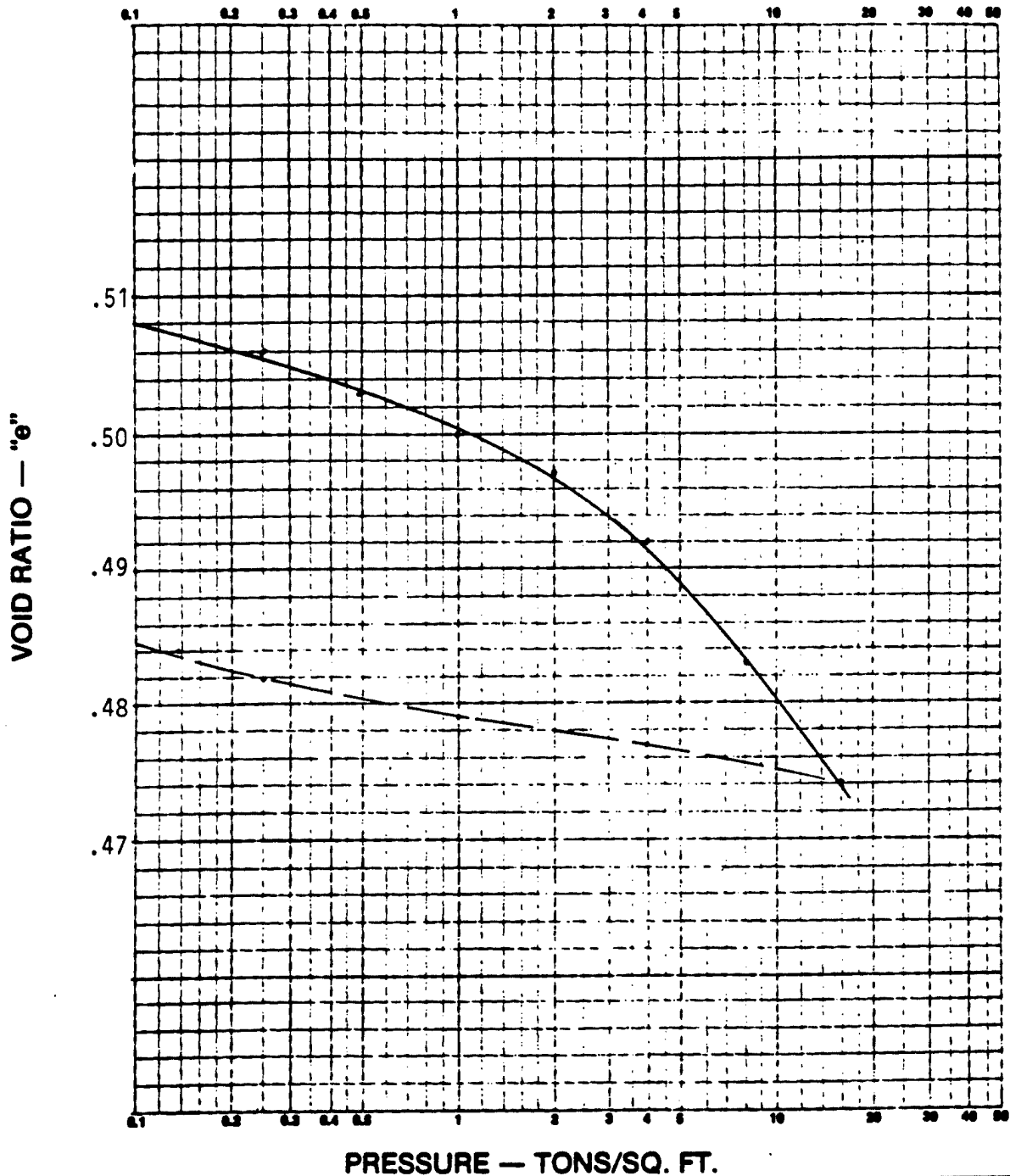
DATE: March 9, 1988  
 JOB NO. 4220 88-226

NOTES: Specimens trimmed to given sizes;  
 consolidated under normal load, well into  
 secondary compression; sheared to given strains  
 at constant rate of 0.00096"/min.



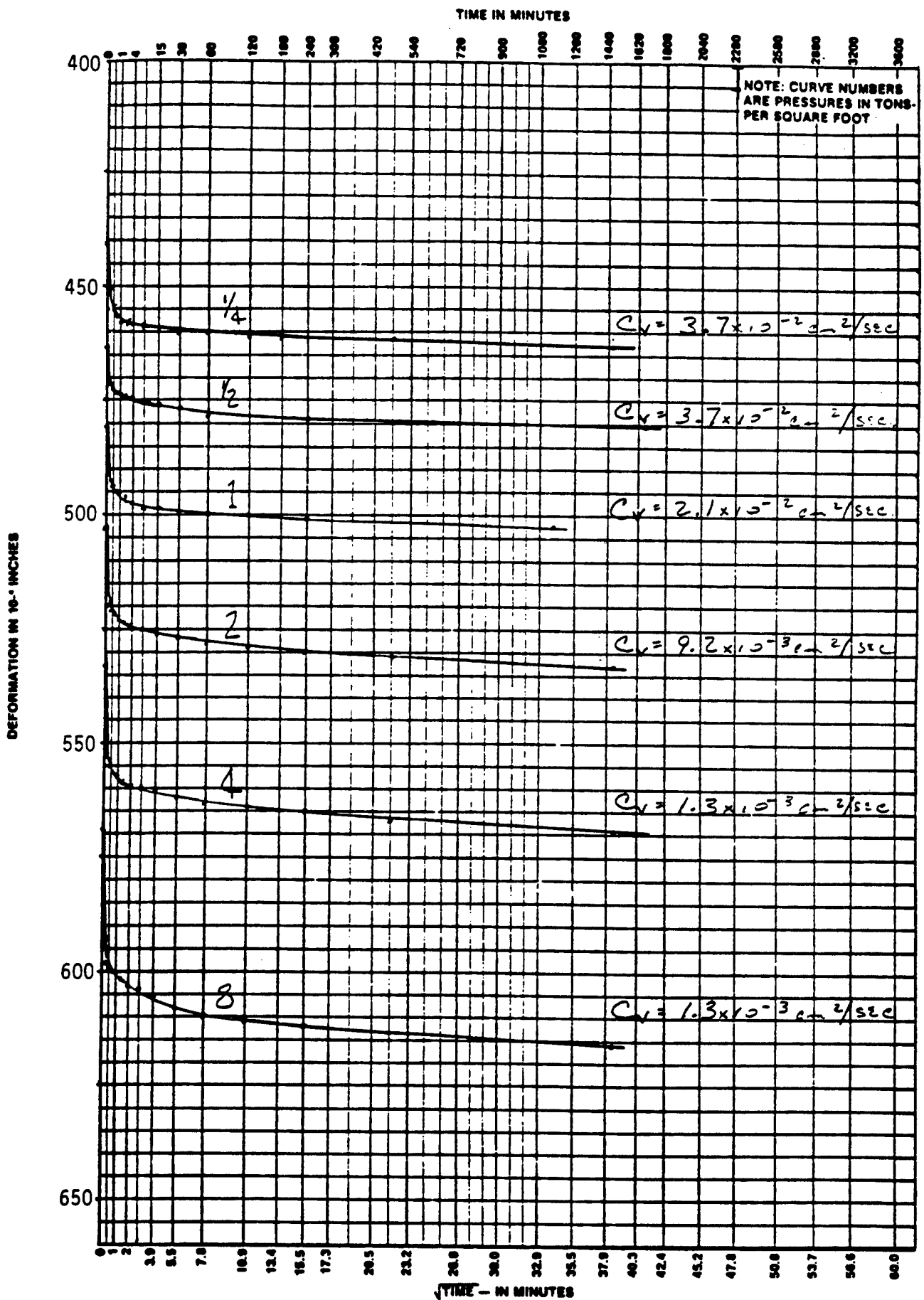
# CONSOLIDATION TEST CURVE

VOID RATIO VS. PRESSURE



Project Chaska Creek Diversion  
 Job No. 4220 88- 226  $G_s=2.67$  Date March 1, 1988  
 Boring No. 87-77M Soil Type (ASTM: D2487) Silt (ML)  
 Sample No. 3 Original Moisture Content, Dry Density 20.0 % 110.0 PCF  
 Depth (FT.) 20-22 (Middle) Liquid Limit 23.2 % Plastic Limit 23.3 %  
 Initial Sample Height (IN.) .796 Preconsolidation Pressure (Pc) 3.3 tsf  
 Sample Diameter (IN.) 2.501 Compression & Recompression Index:  $C_c$  0.03  $C_r$  \_\_\_\_\_

# CONSOLIDATION TEST TIME CURVES



PROJECT Chaska Creek Diversion

JOB. NO. 4220 88-226

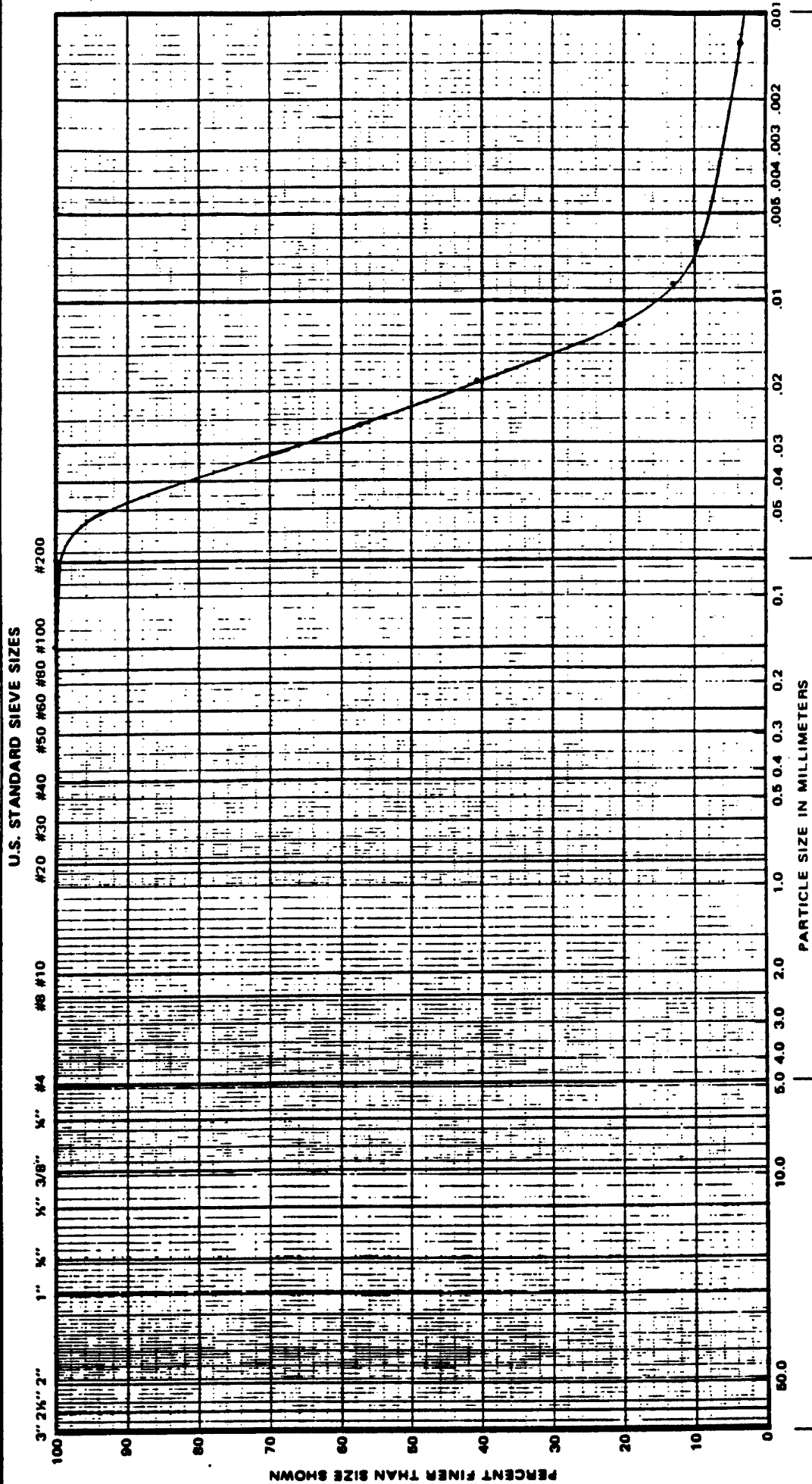
SAMPLE NO. 3

BORING NO. 87-77M

DEPTH 20.0'-22.0' (Middle)

# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE March 8, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-77M SAMPLE NO. 3 DEPTH (FT) 20-22 SOIL TYPE Silt (ML)



FINES

SAND FINE

MEDIUM

COARSE

FINE

GRAVEL

COARSE

ST. PAUL, MN. 55114

CHASKA CREEK DIVERSION

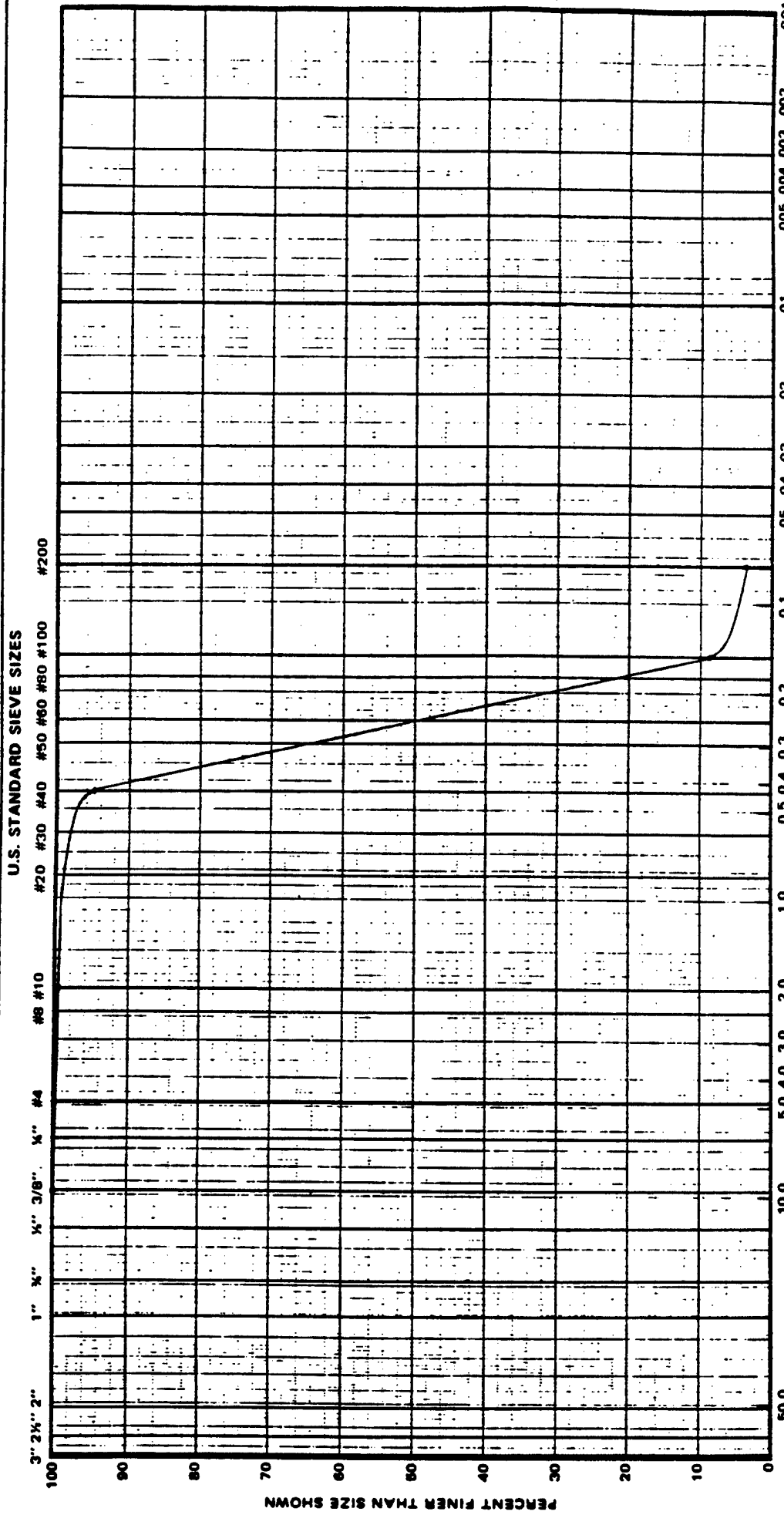
882 CROMWELL AVENUE

SL-31 (7/74)



# GRAIN SIZE DISTRIBUTION CURVE

PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-77M SAMPLE NO. 10 DEPTH (FT) 25.2-25.7 SOIL TYPE Sand, Fine Grained (SP)

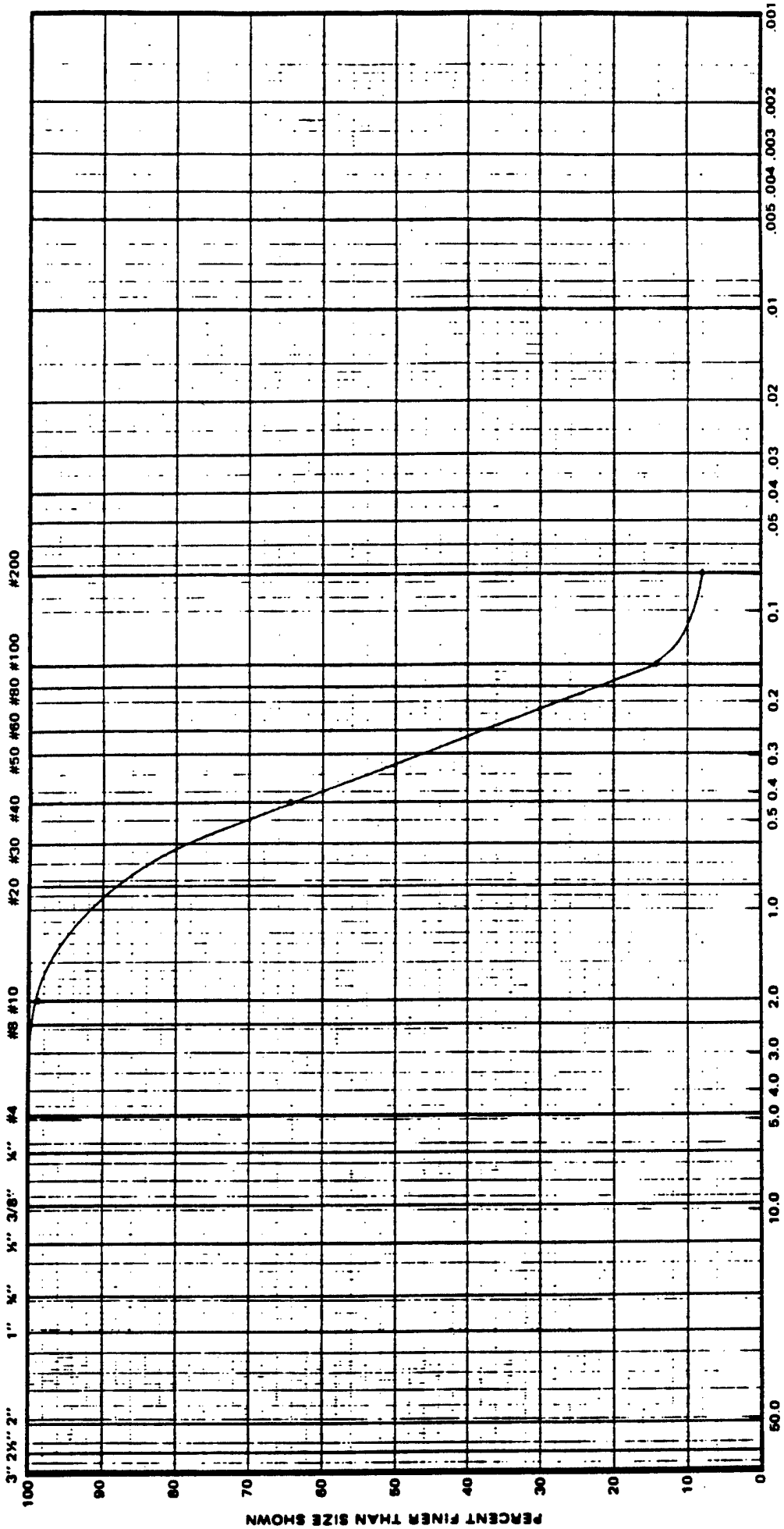


GRAVEL			SAND			FINES		
COARSE	FINE		COARSE	MEDIUM	FINE			

# GRAIN SIZE DISTRIBUTION CURVE

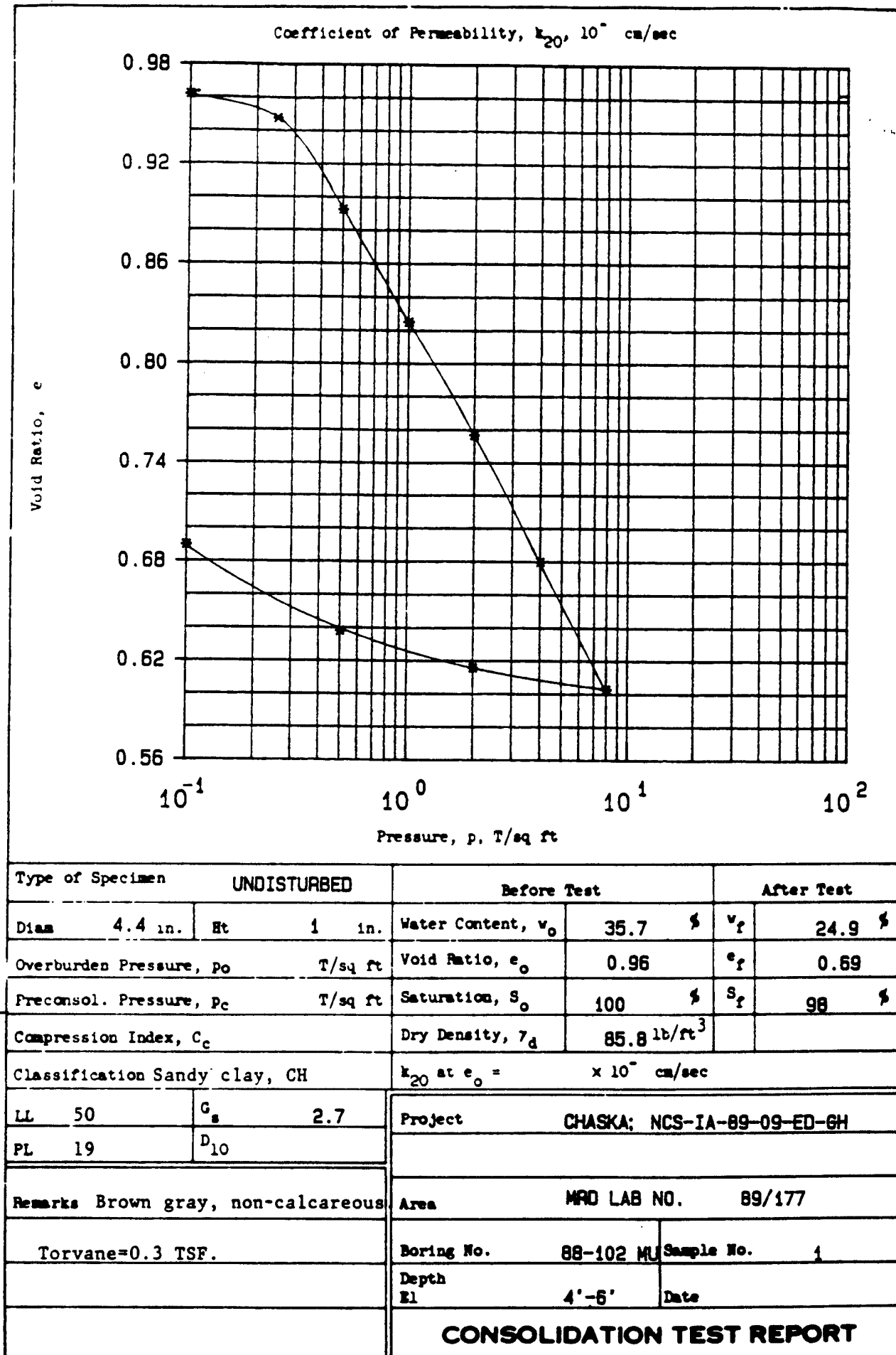
PROJECT Chaska Creek Diversion DATE February 6, 1988  
 REPORTED TO St. Paul District Corps of Engineers JOB NO. #4220 88-226  
 BORING NO. 87-77M SAMPLE NO. 12 DEPTH (FT) 38.2-38.9 SOIL TYPE Sand W/Silt, Fine to Medium Grained (SP-SM)

U.S. STANDARD SIEVE SIZES



GRAVEL			SAND			FINES		
COARSE	FINE		COARSE	MEDIUM	FINE			

Figure C-222



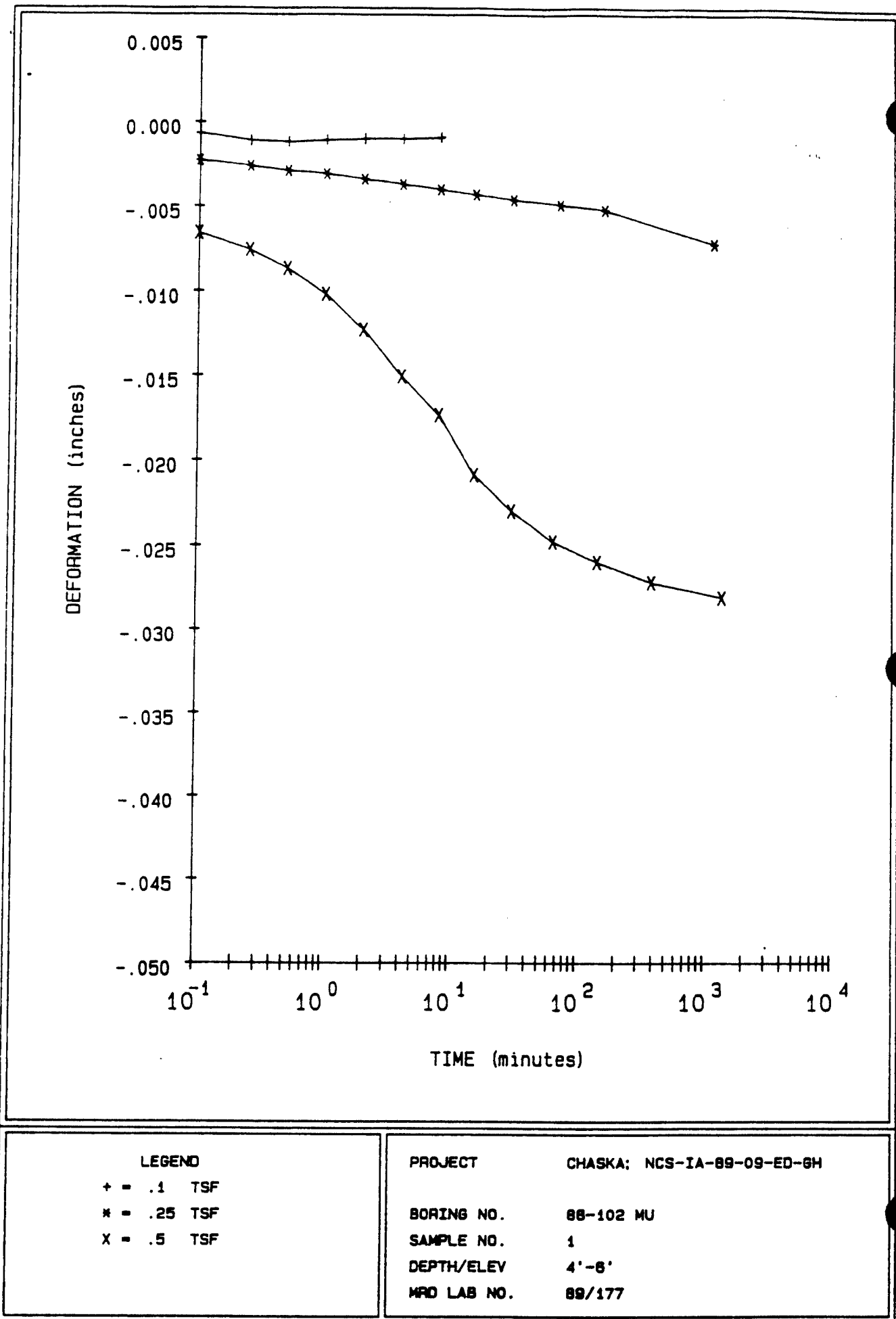


FIGURE 10

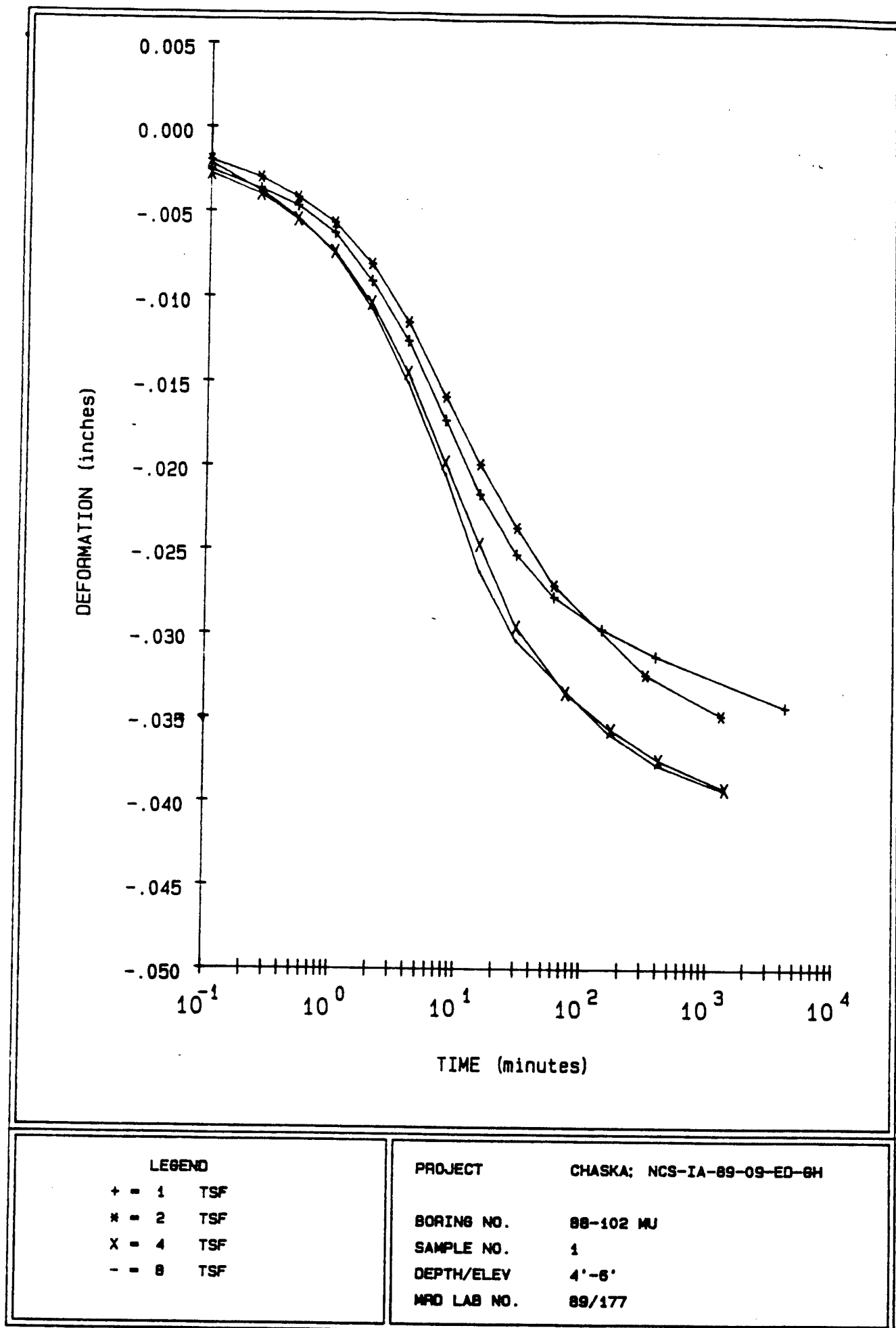
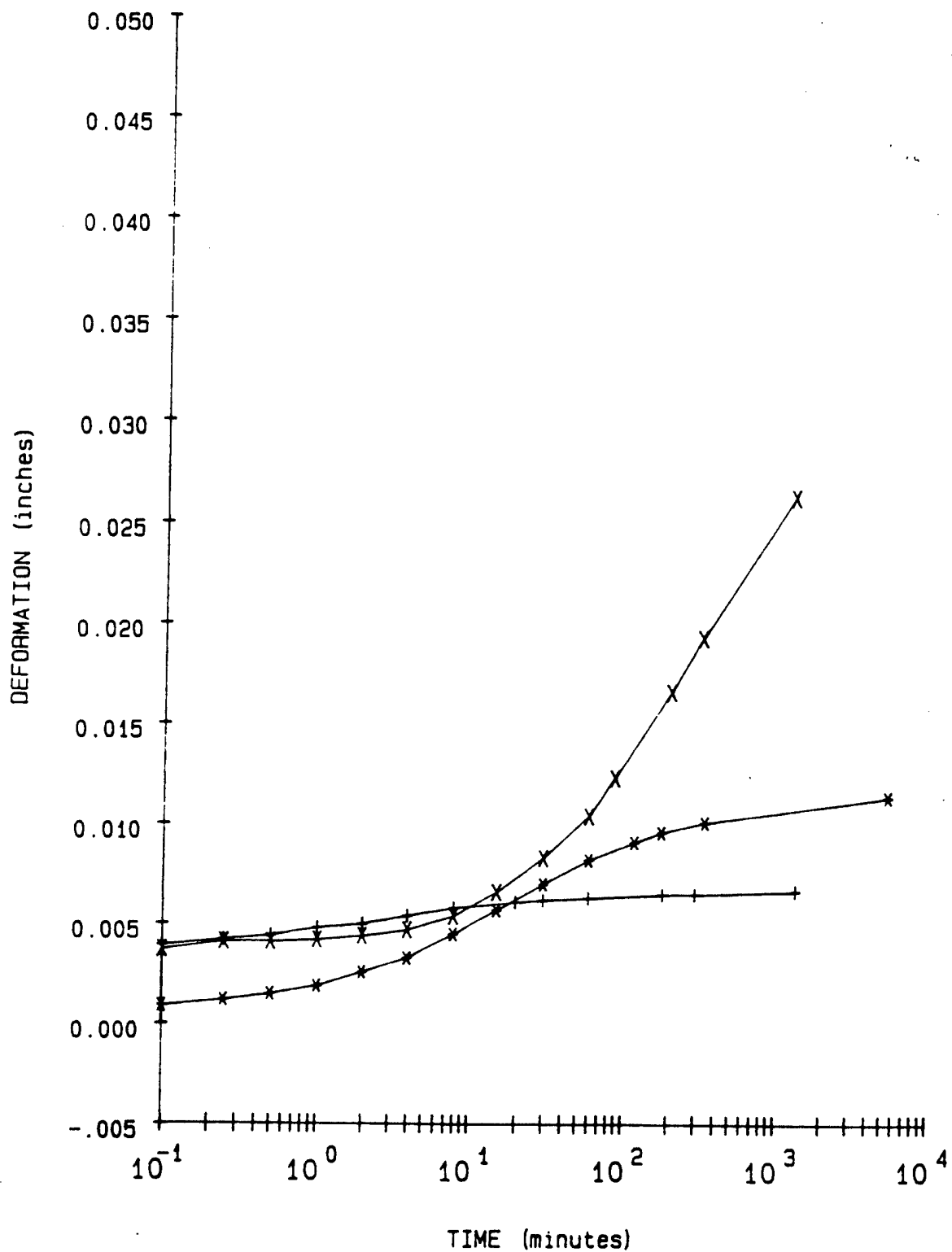


FIGURE 11  
Figure C-225



#### LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = 1 TSF Rebound

#### PROJECT

CHASKA: NCS-IA-89-09-ED-6H

#### BORING NO.

88-102 MU

#### SAMPLE NO.

1

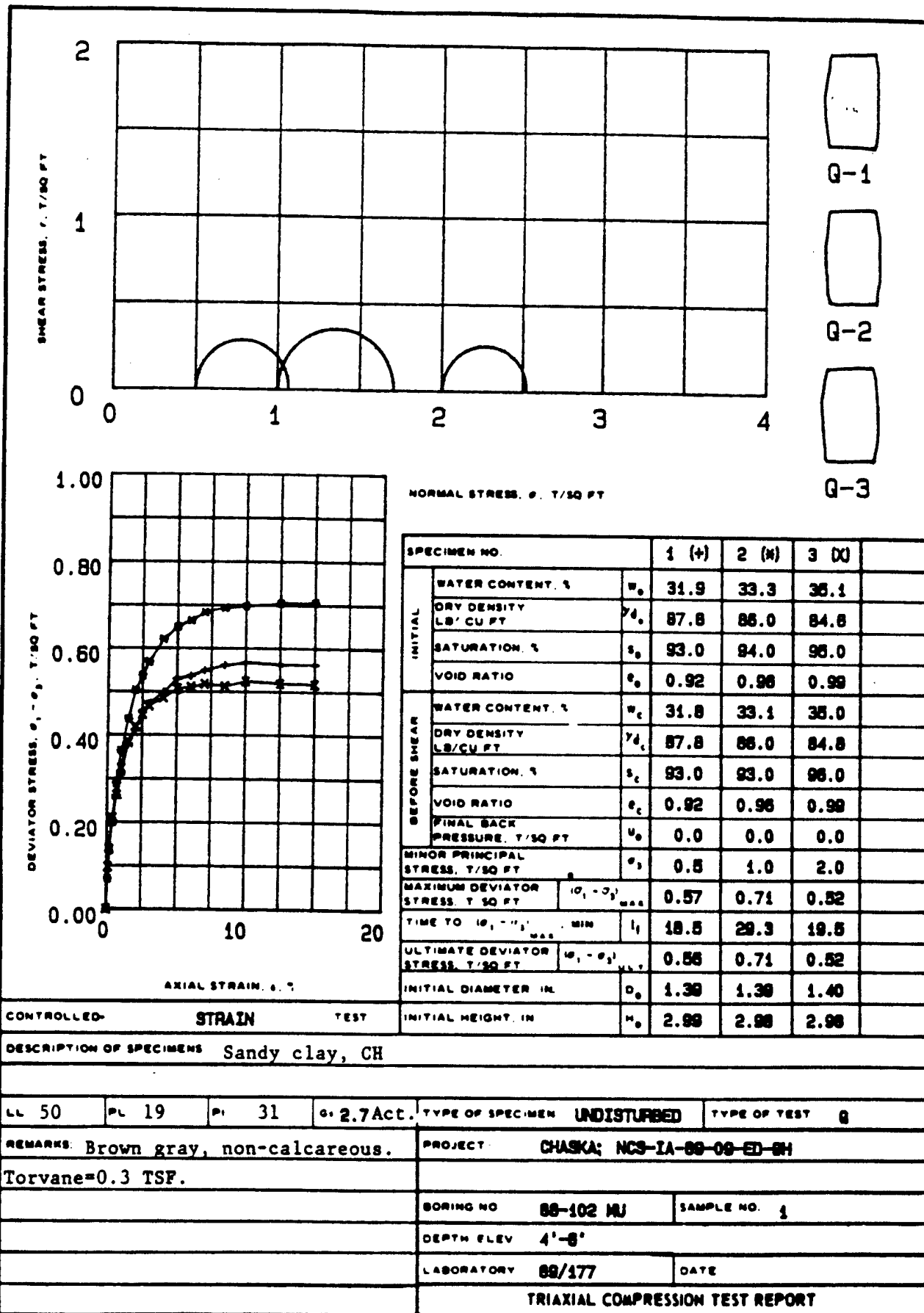
#### DEPTH/ELEV

4'-6'

#### MPO LAB NO.

89/177

FIGURE 12



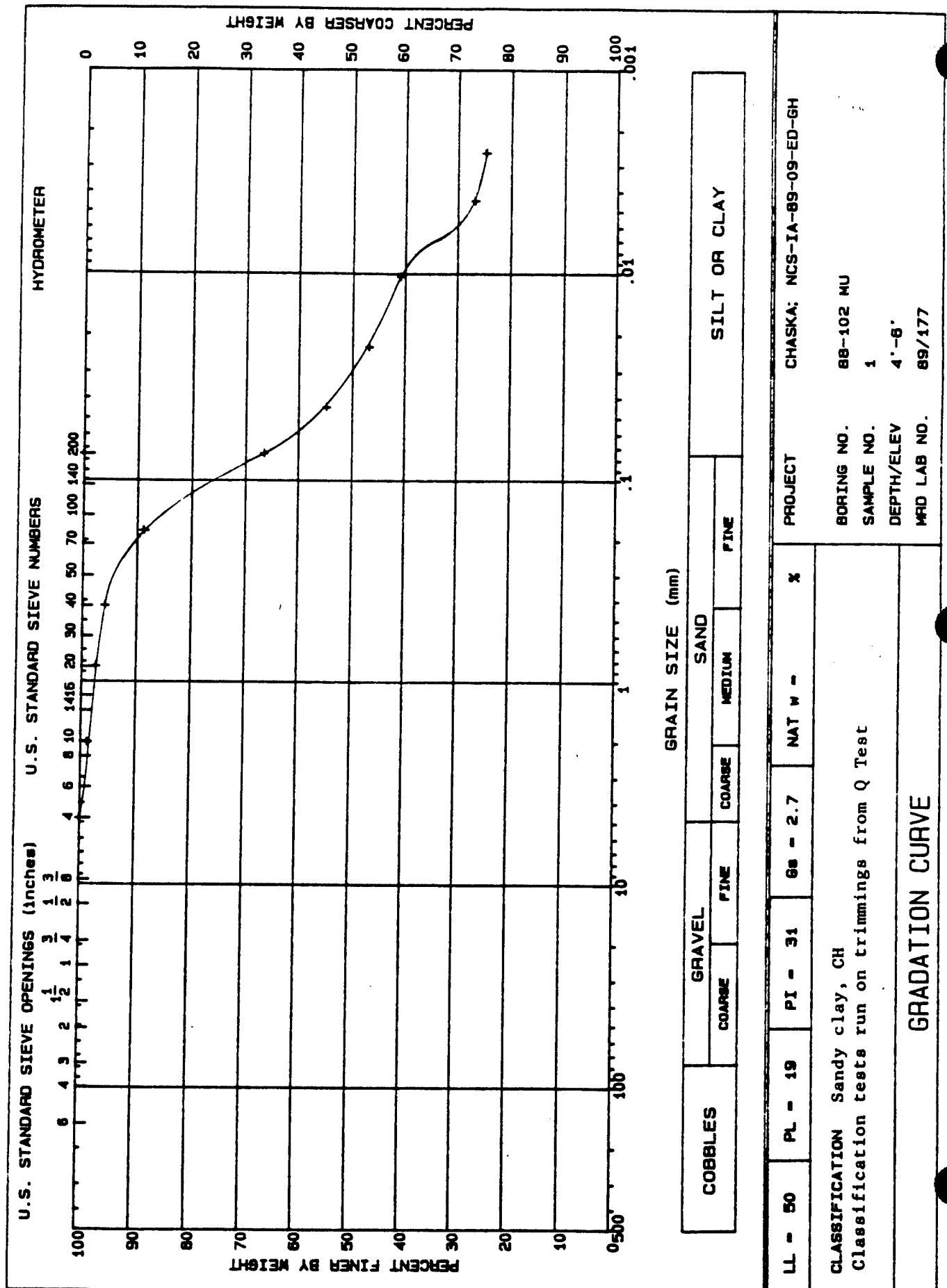
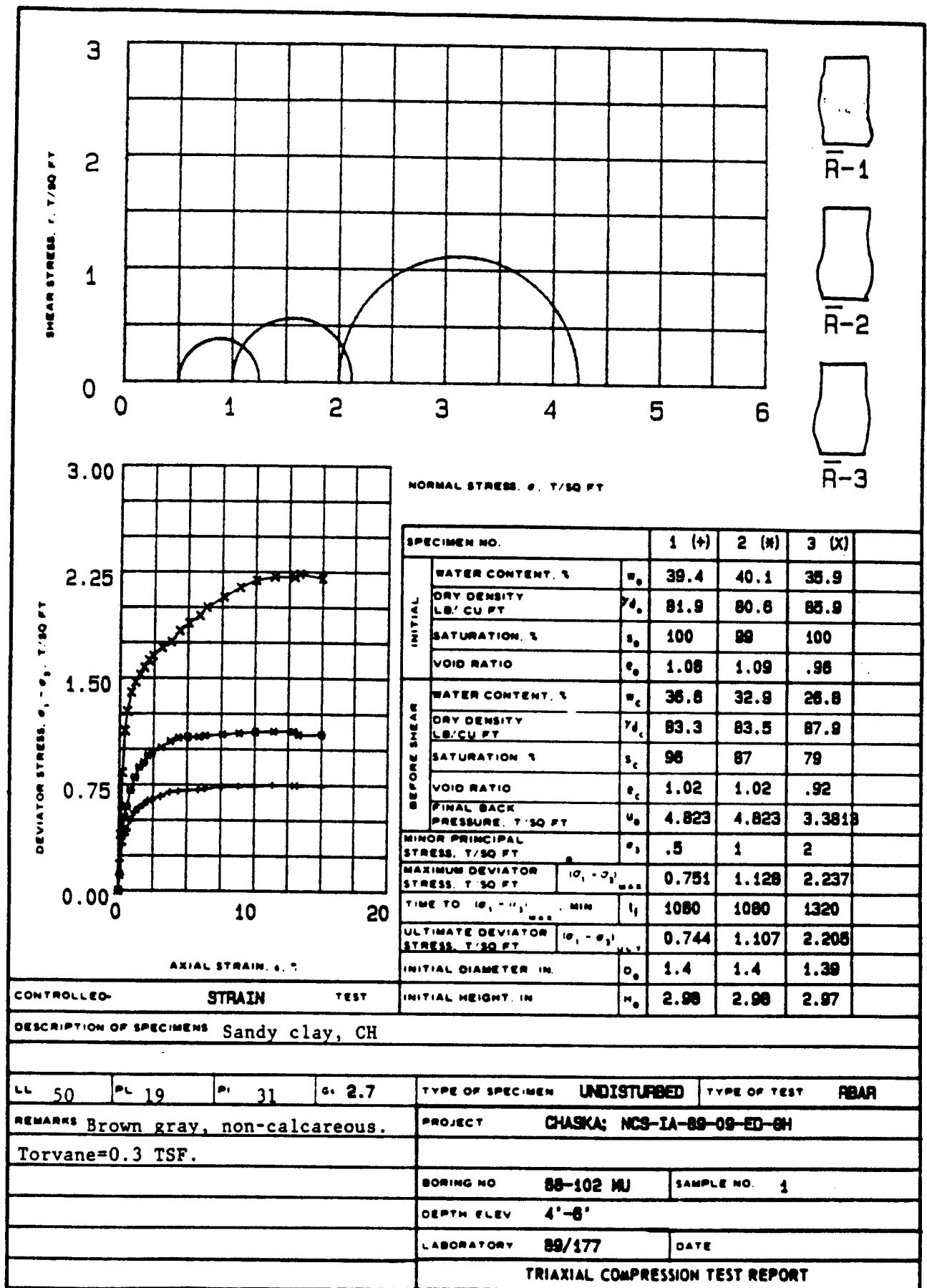
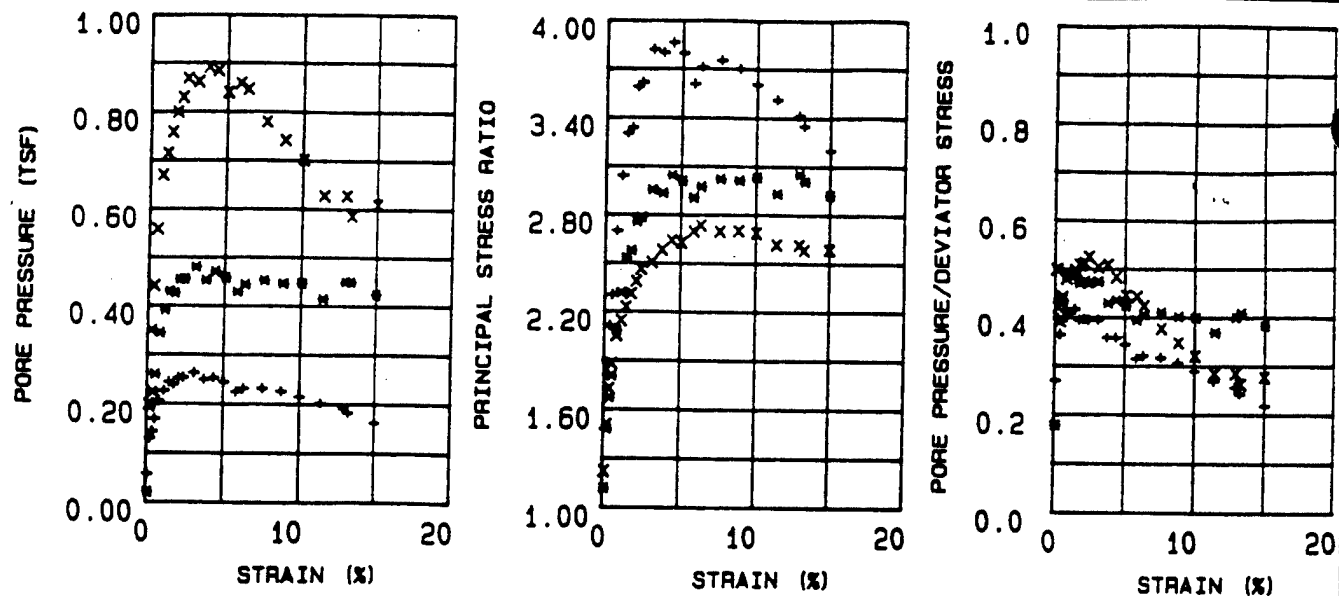


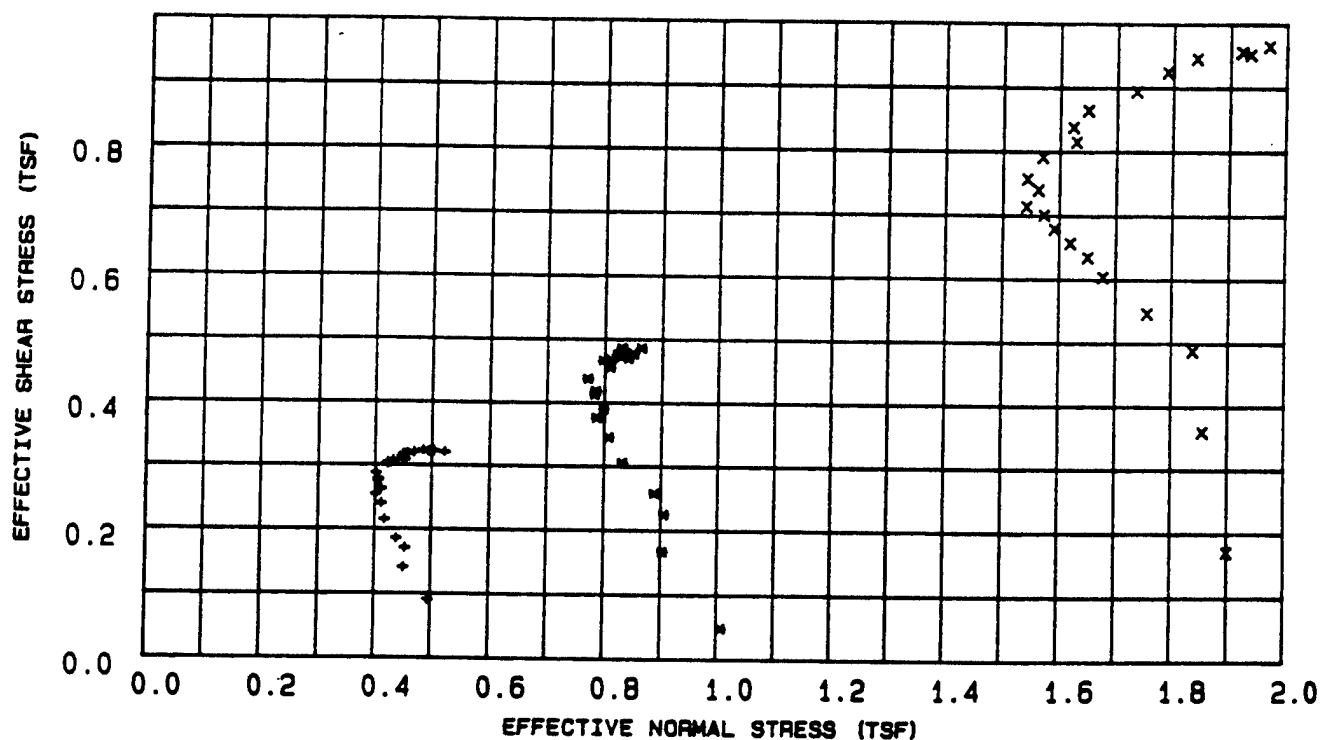
Figure C-228







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

CHASKA; NCS-IA-89-09-ED-6H

BORING NO.

88-102 MU

SAMPLE NO.

1

DEPTH/ELEV

4'-6'

MRO LAB NO.

89/177

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA: NCS-IA-89-09-ED-GH  
 Boring Number : 88-102 MU  
 Sample Number : 1  
 Depth : 4'-6'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.11	0.212	0.057	1.478	0.270	0.495	0.091
30	0.26	0.327	0.130	1.883	0.397	0.451	0.141
45	0.42	0.397	0.144	2.115	0.364	0.454	0.171
60	0.56	0.431	0.169	2.302	0.393	0.438	0.186
90	0.83	0.499	0.206	2.699	0.415	0.417	0.215
120	1.14	0.557	0.227	3.041	0.409	0.411	0.240
150	1.44	0.588	0.245	3.304	0.417	0.401	0.254
180	1.76	0.609	0.240	3.341	0.394	0.411	0.263
210	2.09	0.640	0.253	3.592	0.396	0.405	0.276
240	2.39	0.644	0.254	3.619	0.395	0.405	0.278
300	3.08	0.668	0.264	3.823	0.395	0.401	0.288
360	3.75	0.700	0.250	3.801	0.358	0.423	0.302
420	4.36	0.707	0.253	3.866	0.358	0.422	0.305
480	5.03	0.713	0.245	3.795	0.344	0.432	0.308
540	5.82	0.717	0.225	3.608	0.315	0.452	0.309
600	6.30	0.725	0.232	3.711	0.321	0.448	0.313
720	7.58	0.737	0.232	3.753	0.316	0.450	0.318
840	8.81	0.740	0.226	3.702	0.306	0.457	0.319
960	9.99	0.743	0.215	3.606	0.289	0.469	0.321
1080	11.35	0.751	0.201	3.514	0.269	0.485	0.324
1200	12.86	0.747	0.191	3.417	0.256	0.494	0.322
1320	13.21	0.748	0.182	3.351	0.243	0.503	0.323
1430	15.00	0.744	0.162	3.198	0.218	0.522	0.321

Table 5 - Triaxial R Test Results

Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-102 MU  
 Sample Number : 1  
 Depth : 4'-6'  
 Confining Pressure : 1 TSF

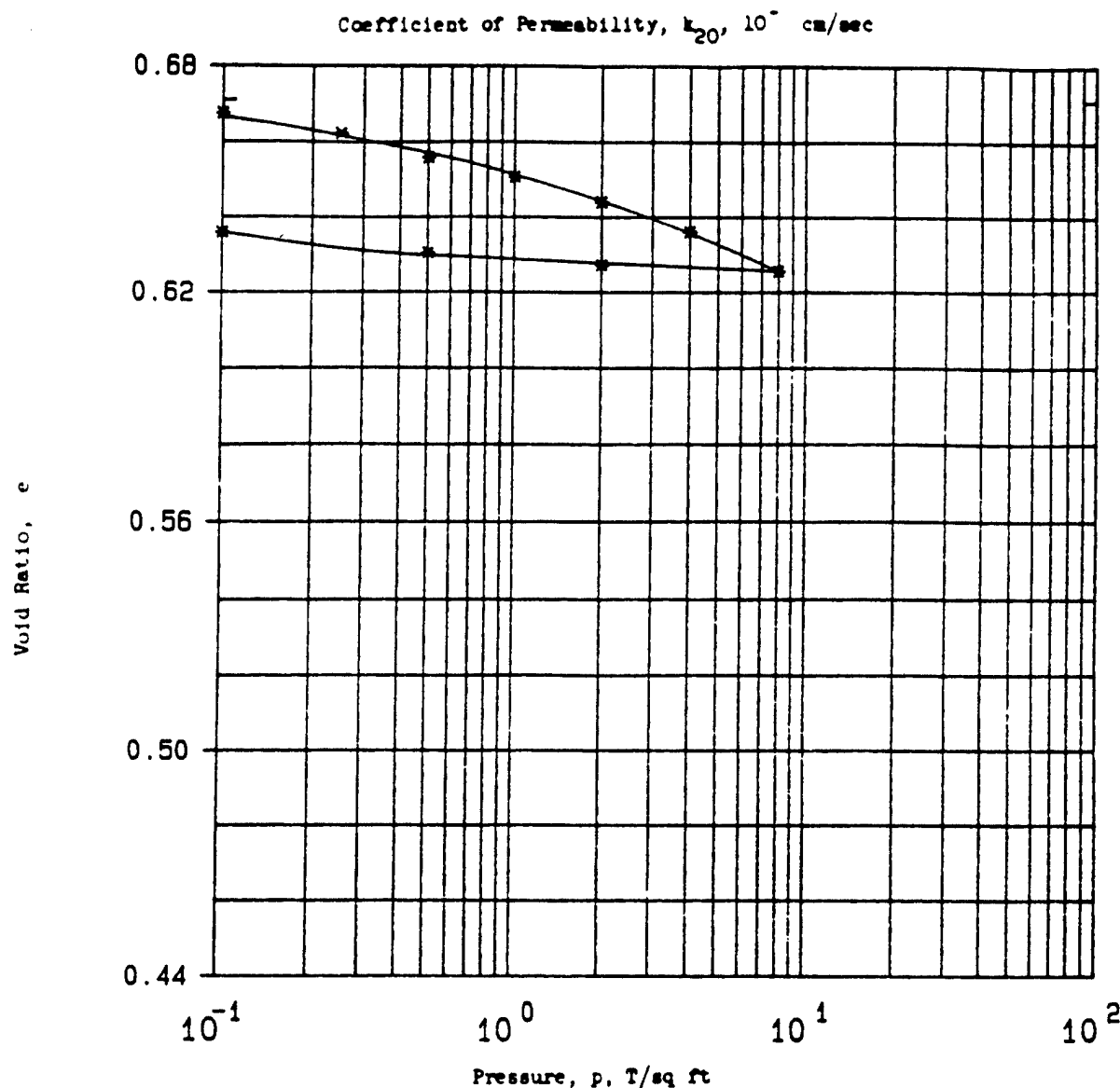
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.114	0.020	1.117	0.178	1.008	0.049
30	0.26	0.387	0.193	1.479	0.500	0.903	0.167
45	0.42	0.521	0.224	1.671	0.430	0.905	0.225
60	0.56	0.597	0.260	1.807	0.436	0.888	0.258
90	0.84	0.710	0.344	2.082	0.486	0.832	0.306
120	1.14	0.802	0.391	2.316	0.488	0.807	0.346
150	1.45	0.874	0.430	2.533	0.493	0.786	0.377
180	1.77	0.906	0.426	2.578	0.470	0.798	0.388
210	2.10	0.958	0.455	2.756	0.475	0.782	0.413
240	2.40	0.971	0.456	2.785	0.470	0.784	0.419
300	3.10	1.014	0.481	2.954	0.474	0.770	0.438
360	3.78	1.058	0.453	2.934	0.429	0.809	0.456
420	4.38	1.083	0.471	3.045	0.435	0.797	0.467
480	5.06	1.087	0.459	3.009	0.423	0.810	0.469
540	5.85	1.089	0.429	2.905	0.394	0.841	0.470
600	6.34	1.097	0.444	2.974	0.406	0.828	0.473
720	7.62	1.106	0.453	3.022	0.410	0.821	0.477
840	8.86	1.115	0.446	3.012	0.401	0.830	0.481
960	10.05	1.124	0.447	3.033	0.399	0.831	0.485
1080	11.43	1.128	0.415	2.929	0.369	0.864	0.475
1200	12.94	1.127	0.450	3.051	0.400	0.829	0.487
1320	13.29	1.102	0.450	3.006	0.409	0.823	0.476
1424	15.00	1.107	0.424	2.922	0.383	0.850	0.478

Table 6 - Triaxial  $\bar{R}$  Test Results

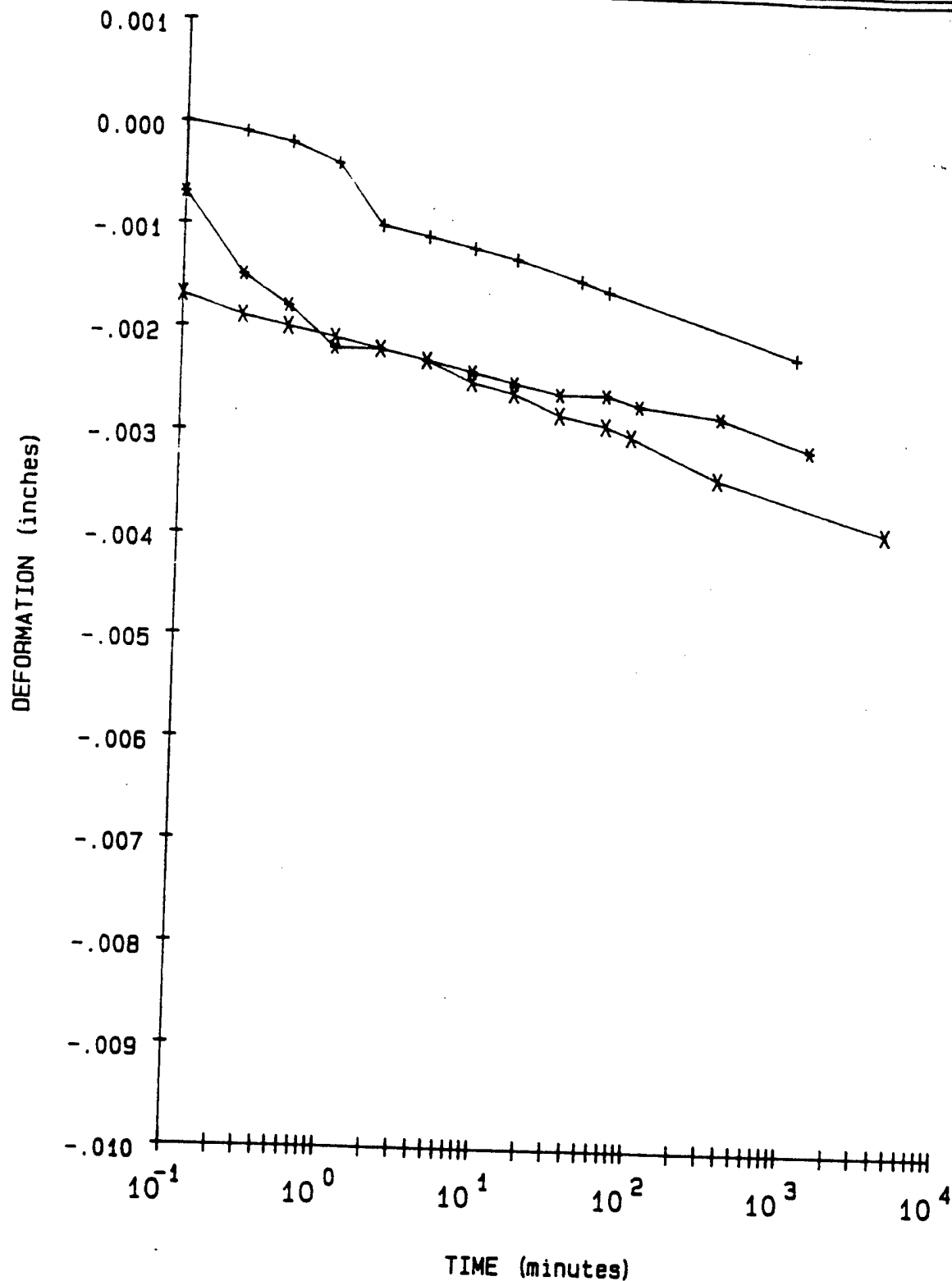
Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-102 MU  
 Sample Number : 1  
 Depth : 4'-6'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.397	0.198	1.220	0.498	1.900	0.171
30	0.26	0.834	0.349	1.505	0.419	1.857	0.360
45	0.42	1.130	0.441	1.725	0.391	1.839	0.488
60	0.56	1.267	0.558	1.878	0.441	1.756	0.547
90	0.84	1.399	0.669	2.051	0.479	1.677	0.604
120	1.14	1.471	0.714	2.144	0.486	1.650	0.635
150	1.44	1.523	0.758	2.227	0.498	1.619	0.657
180	1.77	1.574	0.799	2.310	0.508	1.591	0.679
210	2.10	1.624	0.829	2.387	0.511	1.573	0.701
240	2.40	1.655	0.868	2.462	0.525	1.542	0.714
300	3.10	1.714	0.861	2.505	0.503	1.563	0.740
360	3.77	1.754	0.891	2.582	0.509	1.543	0.757
420	4.38	1.833	0.884	2.642	0.483	1.570	0.791
480	5.05	1.889	0.839	2.627	0.445	1.629	0.815
540	5.85	1.941	0.858	2.699	0.443	1.623	0.838
600	6.34	2.001	0.846	2.735	0.423	1.649	0.864
720	7.62	2.072	0.779	2.696	0.376	1.734	0.894
840	8.85	2.141	0.741	2.701	0.347	1.789	0.924
960	10.04	2.192	0.701	2.687	0.320	1.842	0.946
1080	11.41	2.216	0.627	2.614	0.284	1.922	0.956
1200	12.93	2.215	0.627	2.613	0.284	1.921	0.956
1320	13.28	<u>2.237</u>	<u>0.585</u>	2.581	0.262	1.969	0.965
1425	15.00	2.205	0.609	2.586	0.277	1.936	0.952

not enough undisturbed soil for R-bar test



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	1 in.	Water Content, $w_o$	23.1 %	$w_f$	23.3 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	0.67	$e_f$	0.64
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	93 %	$S_f$	99 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	101.2 lb/ft <sup>3</sup>		
Classification Silt, ML				$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec			
LL	23	$G_s$	2.71	Project			
PL	19	$D_{10}$		CHASKA; NCS-IA-89-09-ED-GH			
Remarks Brown gray, calcareous.				Area			
Sample may have dried due to a				MRD LAB NO. 89/177			
hole in the plastic field				Boring No. 88-102 MU		Sample No. 3	
packaging.				Depth El 23'-25'		Date	
				<b>CONSOLIDATION TEST REPORT</b>			



LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

CHASKA: NCS-IA-89-09-ED-8H

BORING NO.

88-102 MU

SAMPLE NO.

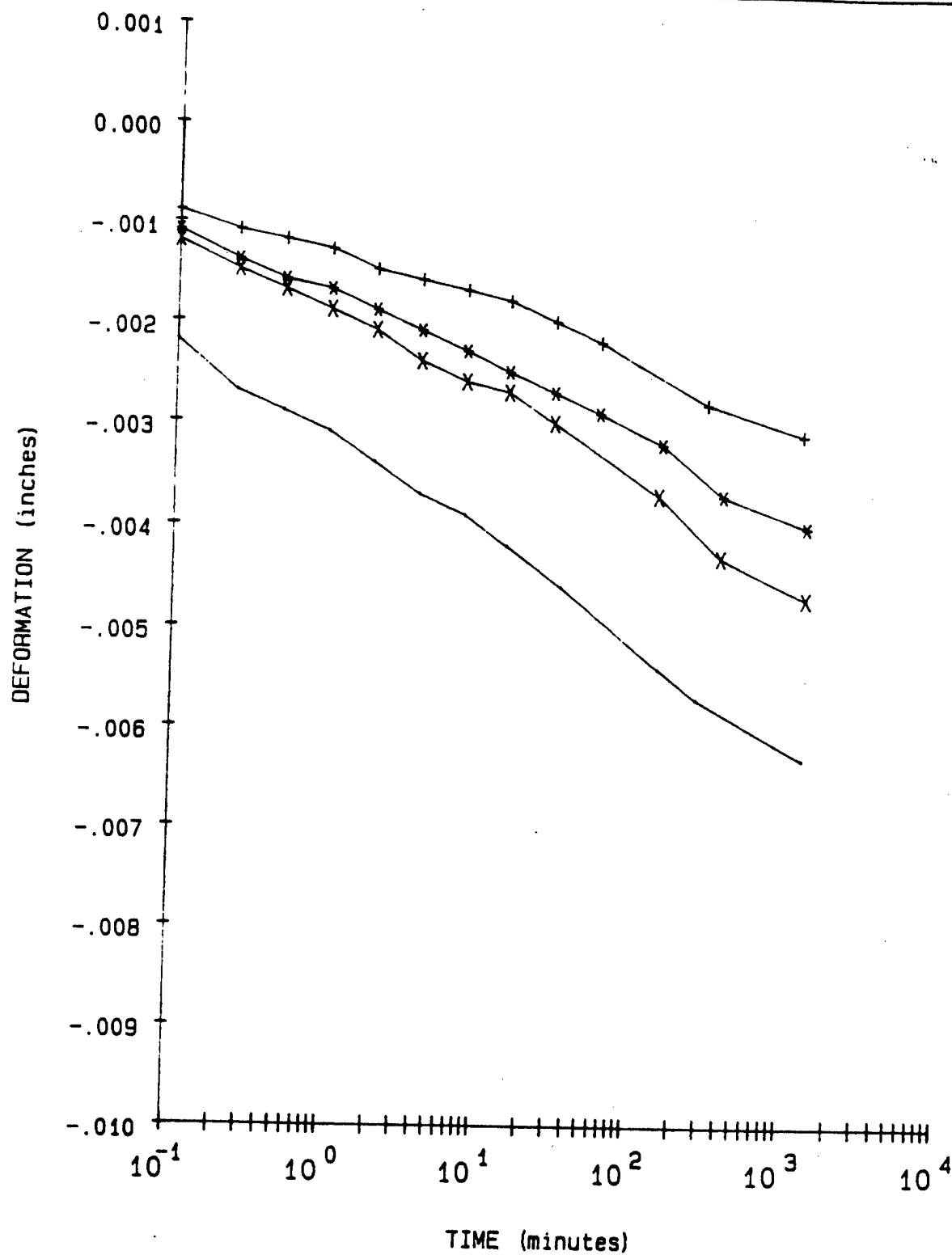
3

DEPTH/ELEV

23'-25'

MRD LAB NO.

89/177



#### LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

#### PROJECT

CHASKA; NCS-IA-89-09-ED-6H

#### BORING NO.

88-102 MU

#### SAMPLE NO.

3

#### DEPTH/ELEV

23'-25'

#### MRO LAB NO.

89/177



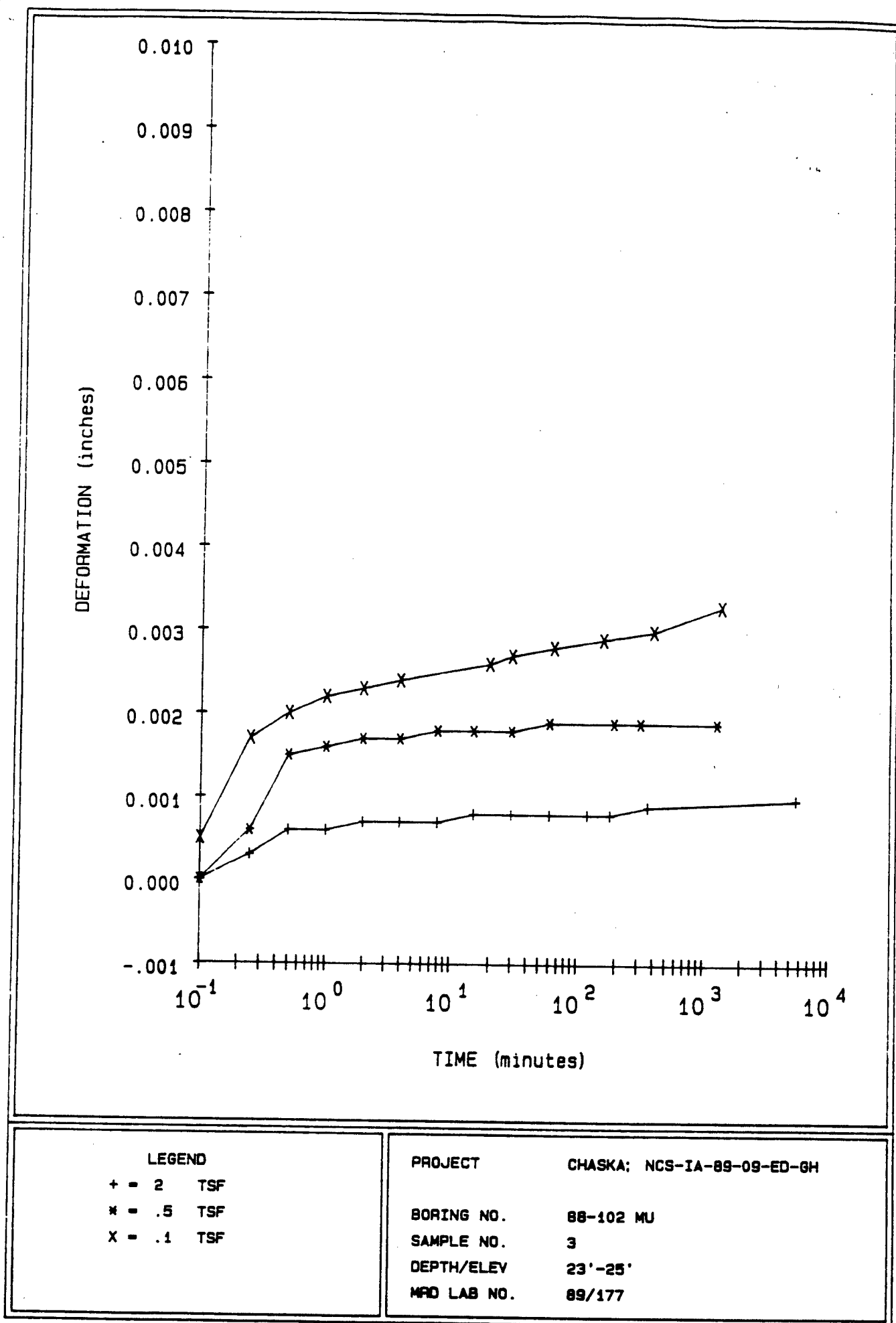


FIGURE 9 Figure C-237

# Consolidation Test Data

Table 2  
Project

CHASKA; NCS-IA-89-09-ED-GH

Boring No. 88-102 MU  
Sample No. 3  
Depth/Elev. 23'-25'  
MRD Lab No. 89/177

$$\begin{aligned} G_s &= 2.71 \\ e_o &= 0.671 \\ 0.42e_o &= 0.282 \end{aligned}$$

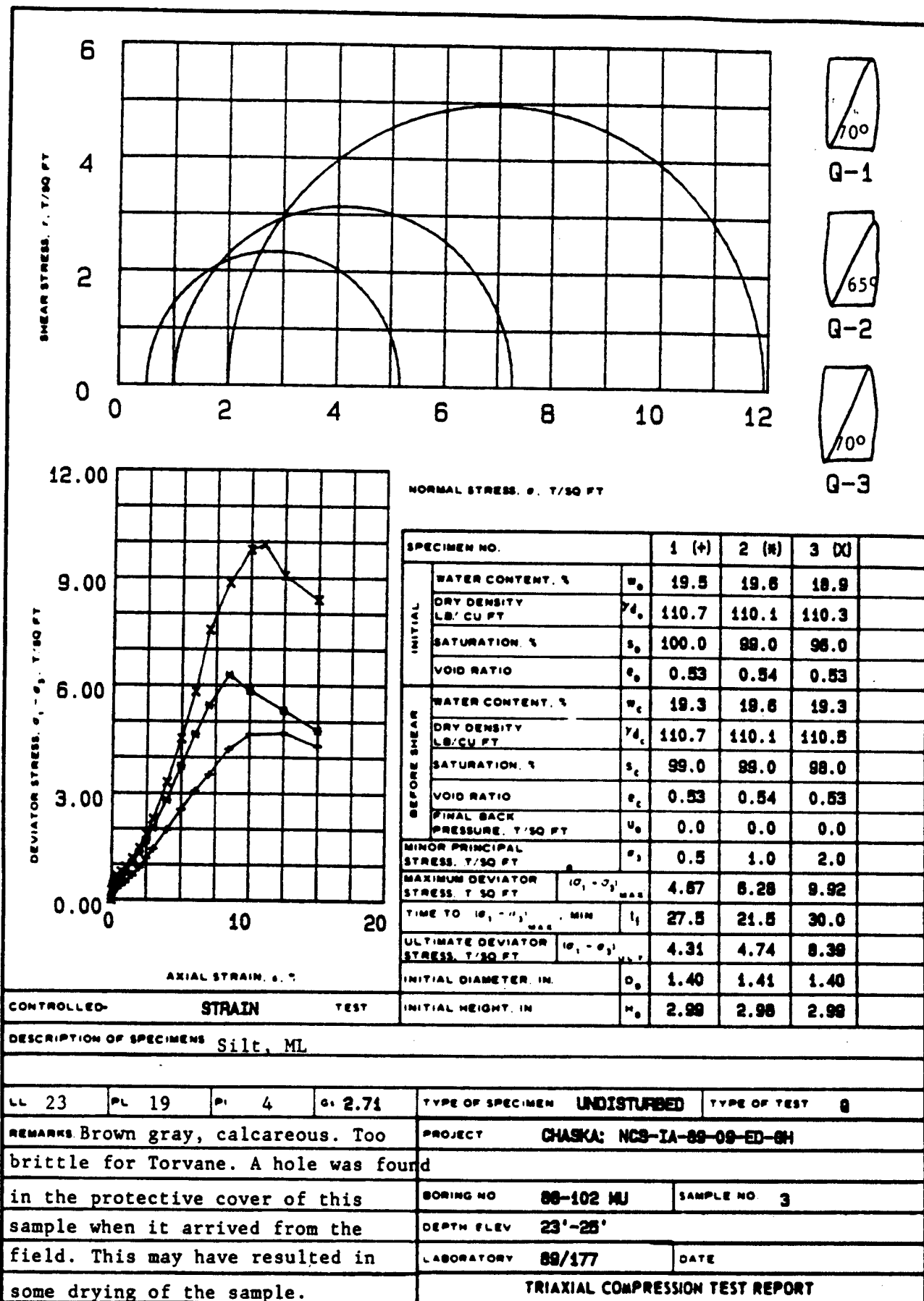
Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
23.1	382.7	101.2	0.671	0.10	93.2
23.3	382.7	101.4	0.667	0.25	94.6
23.3	382.7	101.7	0.662	0.50	95.4
23.3	382.7	102.1	0.656	1.00	96.3
23.3	382.7	102.5	0.651	2.00	97.1
23.3	382.7	102.9	0.644	4.00	98.1
23.3	382.7	103.4	0.636	8.00	99.3
23.3	382.7	104.0	0.625	2.00	100.0
23.3	382.7	103.9	0.627	0.50	100.0
23.3	382.7	103.7	0.630	0.10	99.3
23.3	382.7	103.4	0.636		

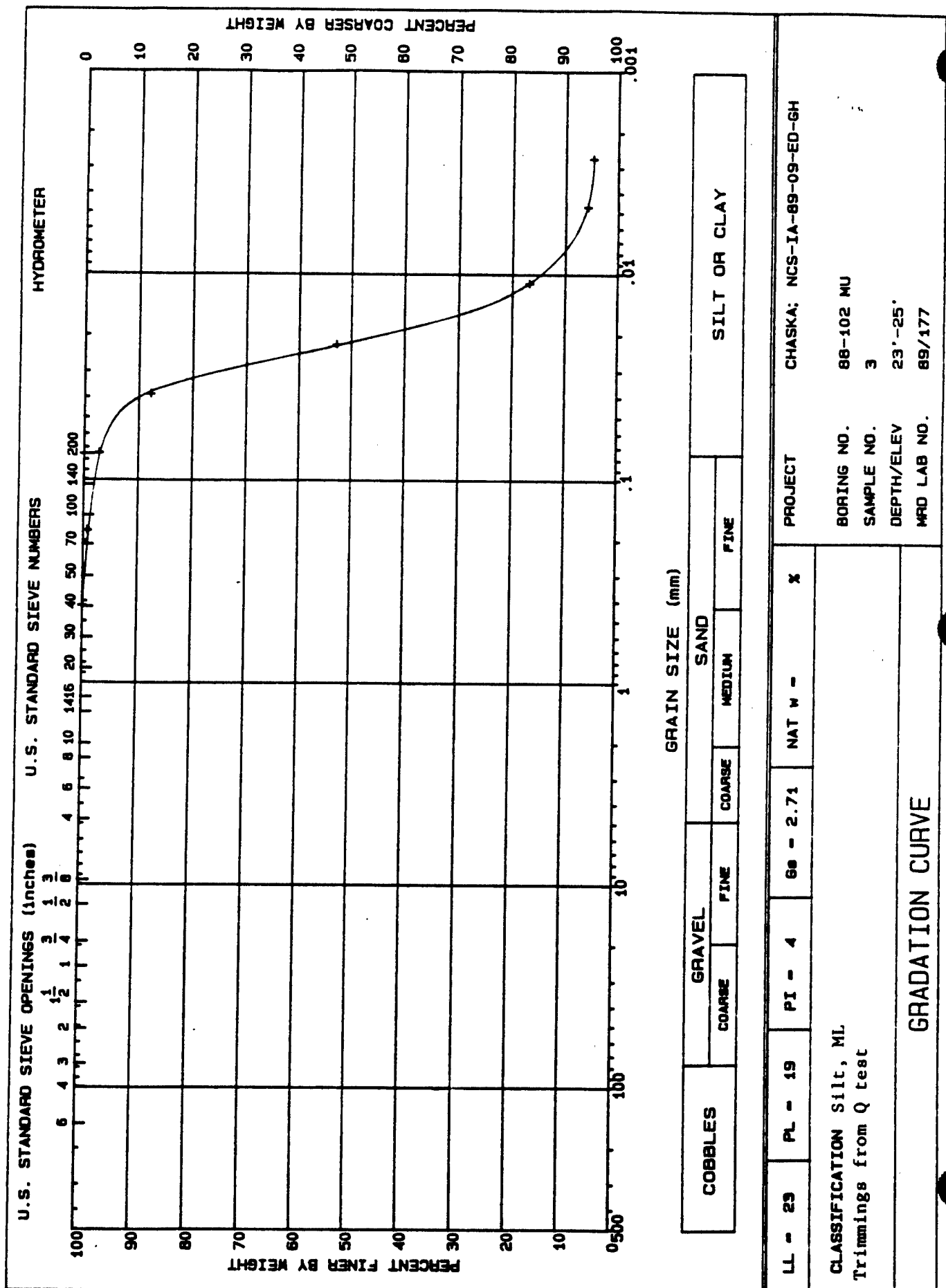
Axial Strain (%)

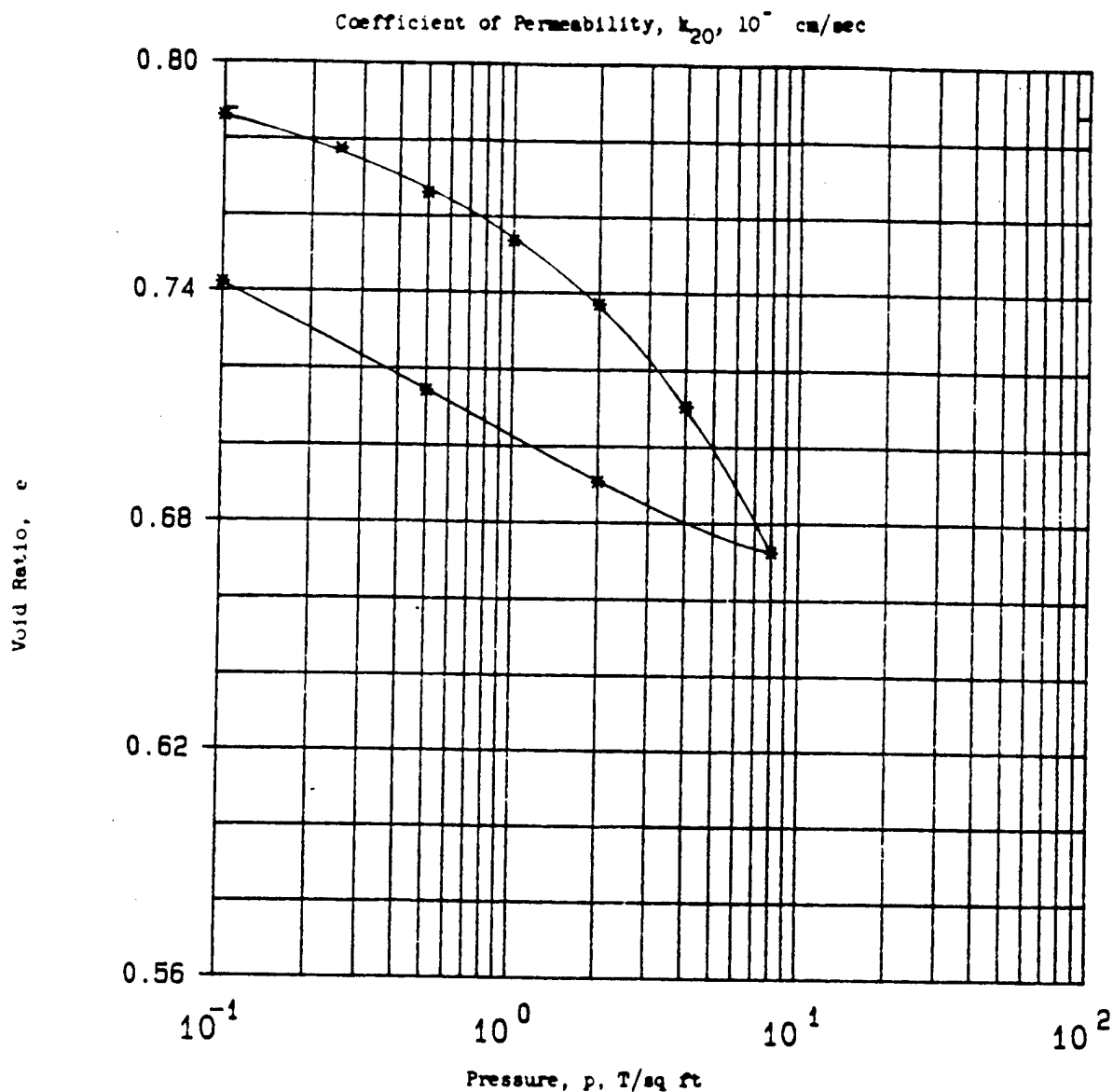
- 1
- 2
- 3
- 4
- 5

Void Ratio

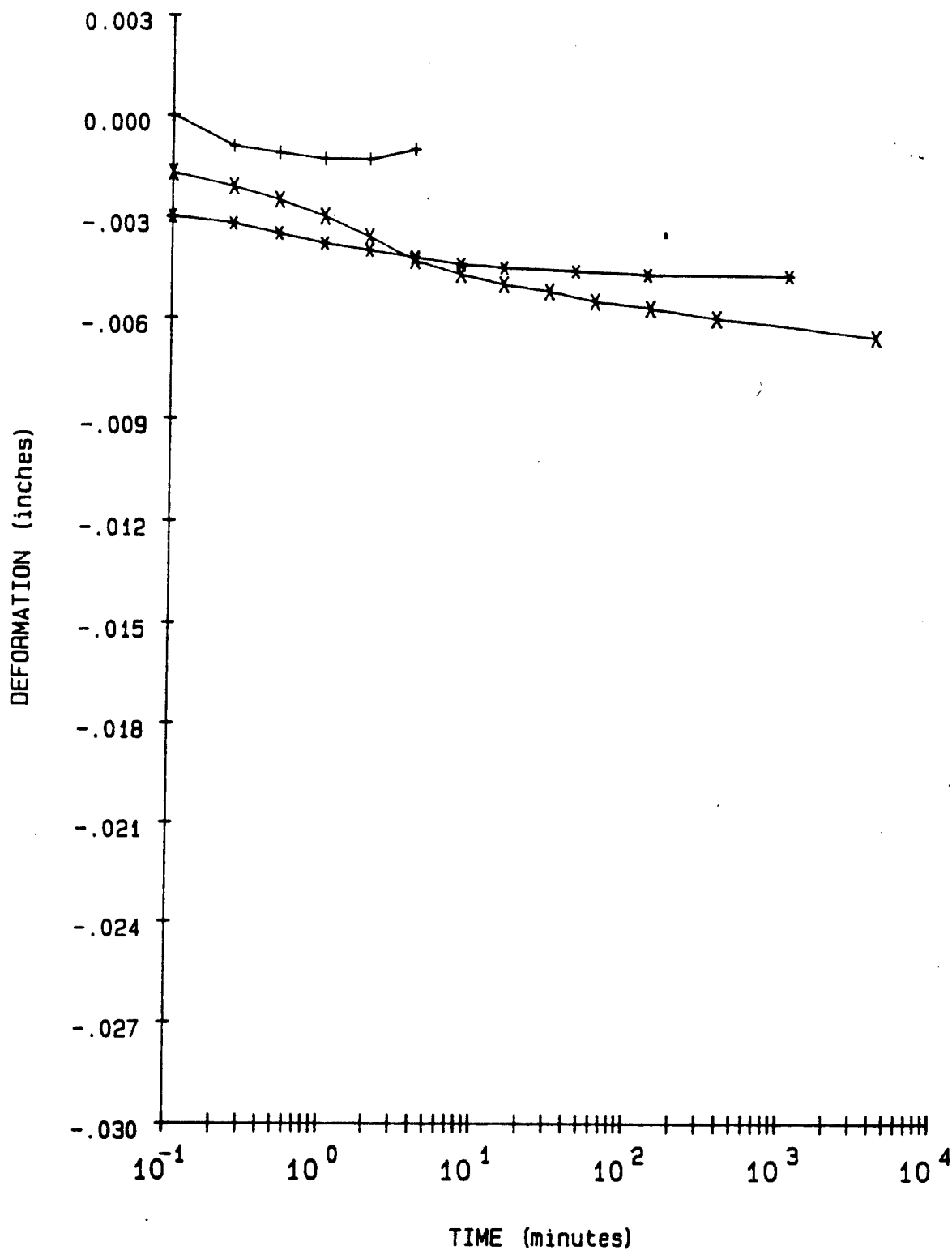
- 0.654
- 0.638
- 0.621
- 0.604
- 0.588







Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.4 in.	Ht	1 in.	Water Content, $w_o$	28.4 %	$w_f$	27.6 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	0.79	$e_f$	0.74
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	99 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	95.6 lb/ft <sup>3</sup>		
Classification		Lean clay, CL		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL	46	$G_s$	2.74	Project			
PL	18	$D_{10}$					
Remarks				CHASKA: NCS-IA-89-09-ED-GH			
				Area			
Torvane=0.8 TSF.				MRD LAB NO.		89/177	
				Boring No.		88-102 MU	
				Sample No.		5	
				Depth		43'-45'	
				Date			
				<b>CONSOLIDATION TEST REPORT</b>			



LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

CHASKA; NCS-IA-89-09-ED-6H

BORING NO.

88-102 MU

SAMPLE NO.

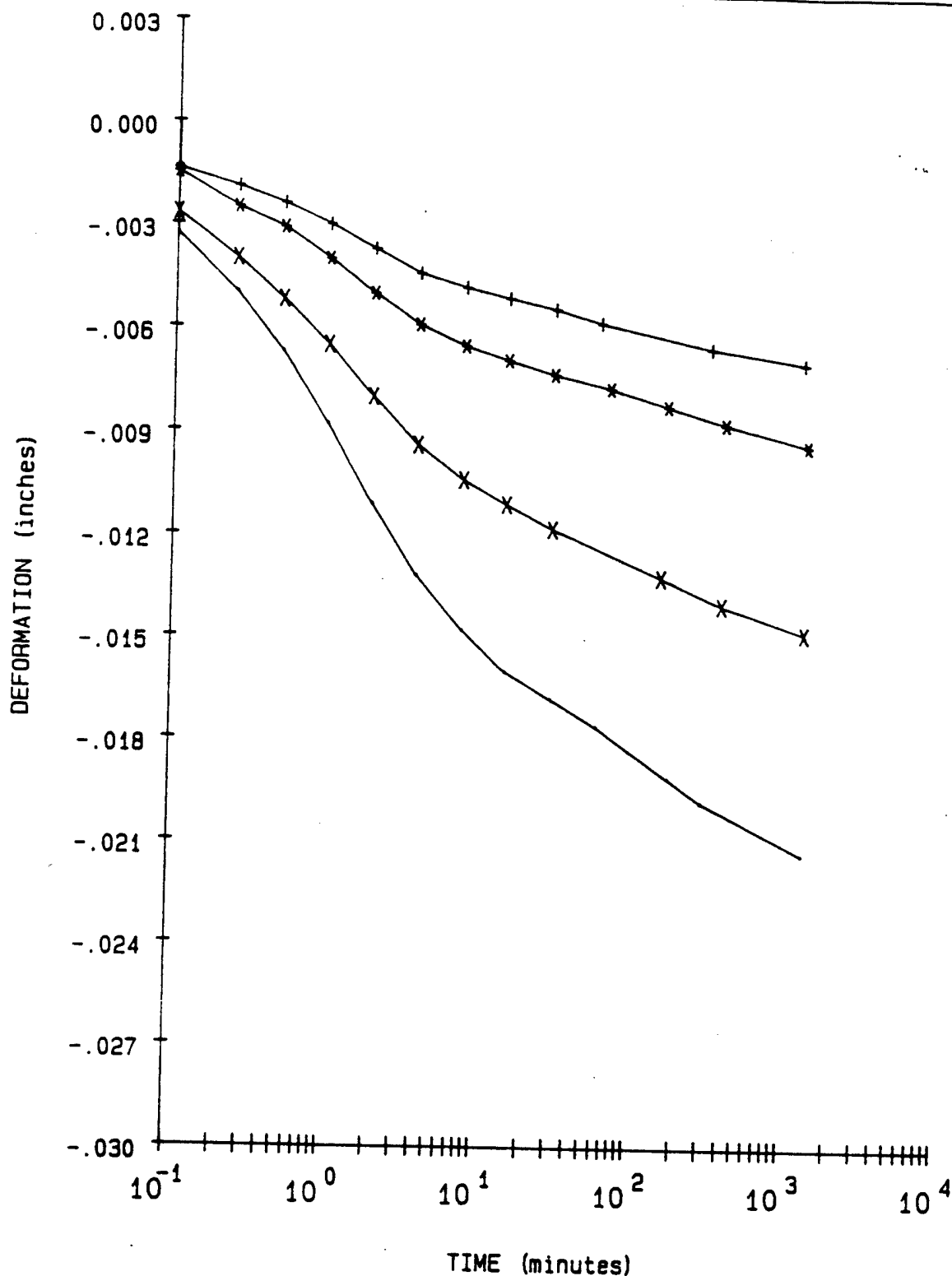
5

DEPTH/ELEV

43'-45'

MRD LAB NO.

89/177



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

CHASKA; NCS-IA-89-09-ED-GH

BORING NO.

88-102 MU

SAMPLE NO.

5

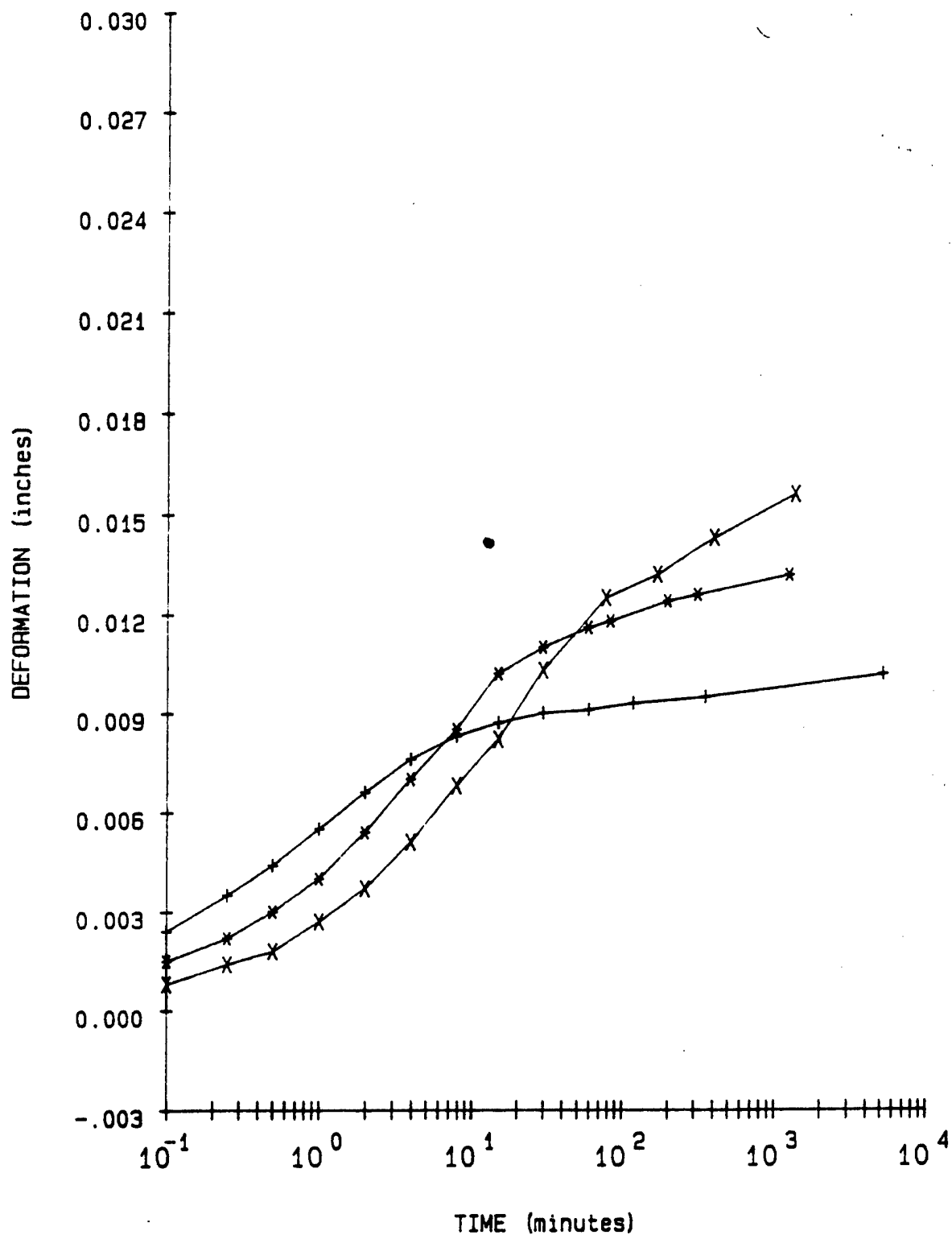
DEPTH/ELEV

43'-45'

MFO LAB NO.

89/177

FIGURE 9 Figure C-243



LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT

CHASKA: NCS-IA-89-09-ED-6H

BORING NO.

88-102 MU

SAMPLE NO.

5

DEPTH/ELEV

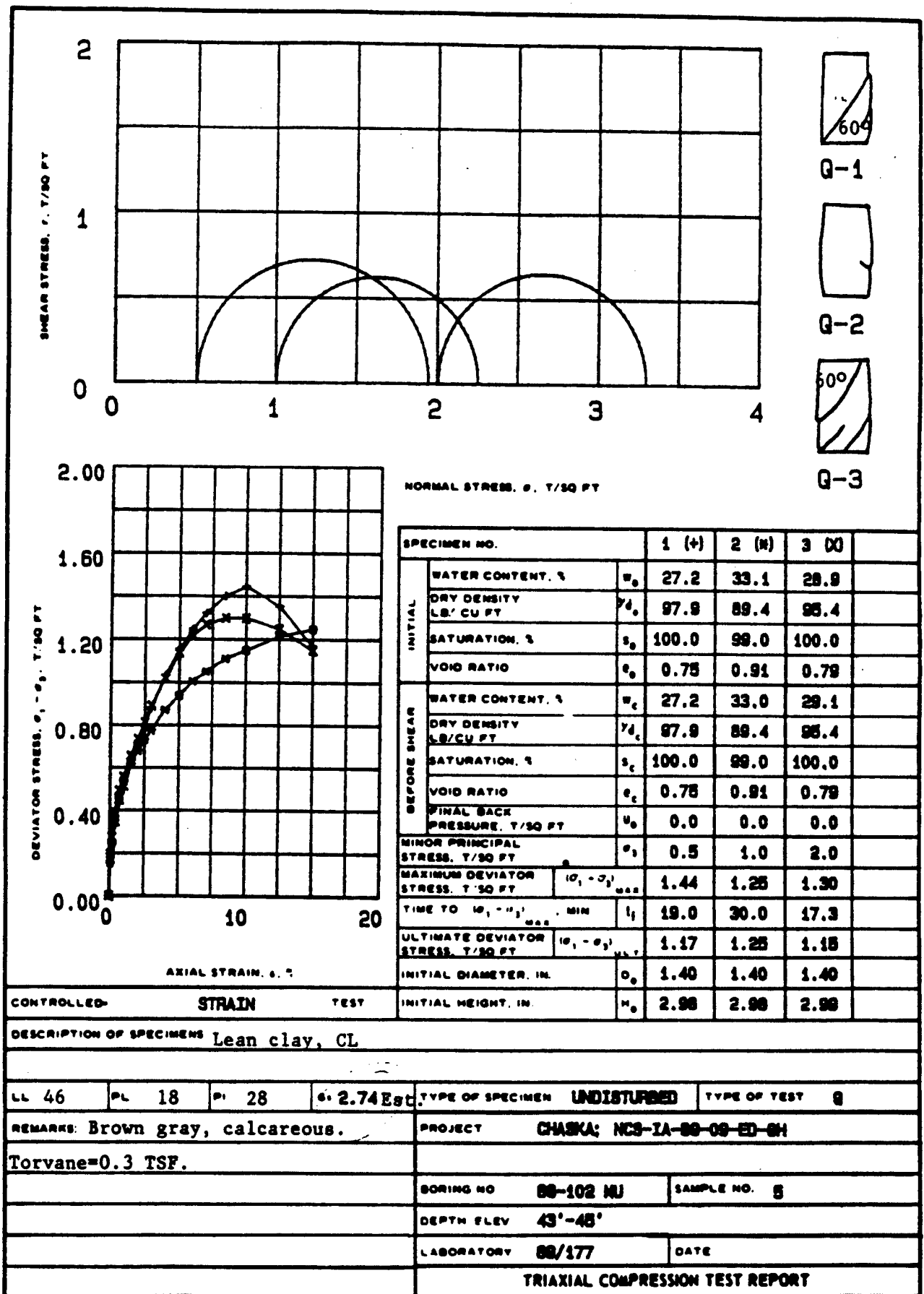
43'-45'

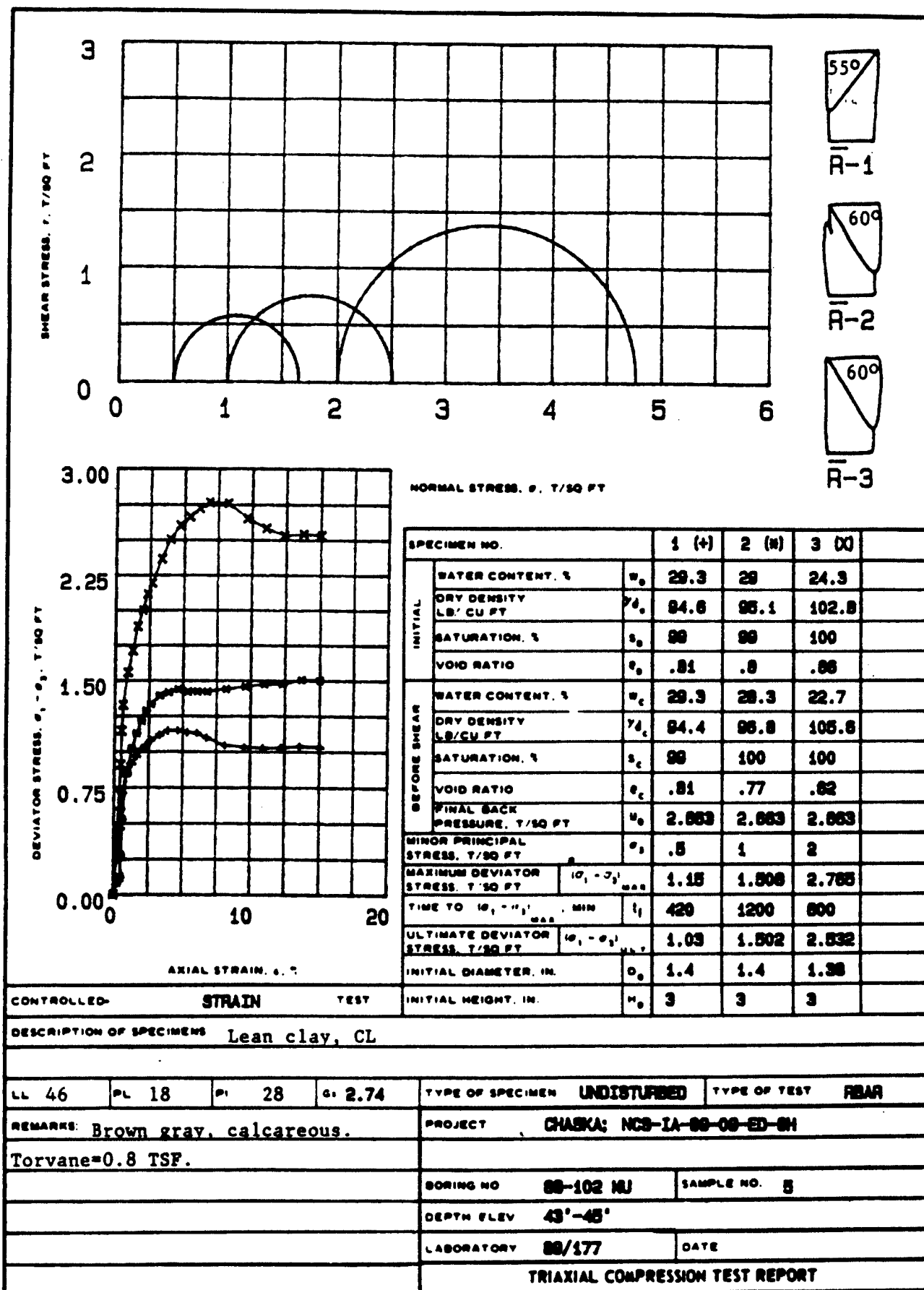
MRO LAB NO.

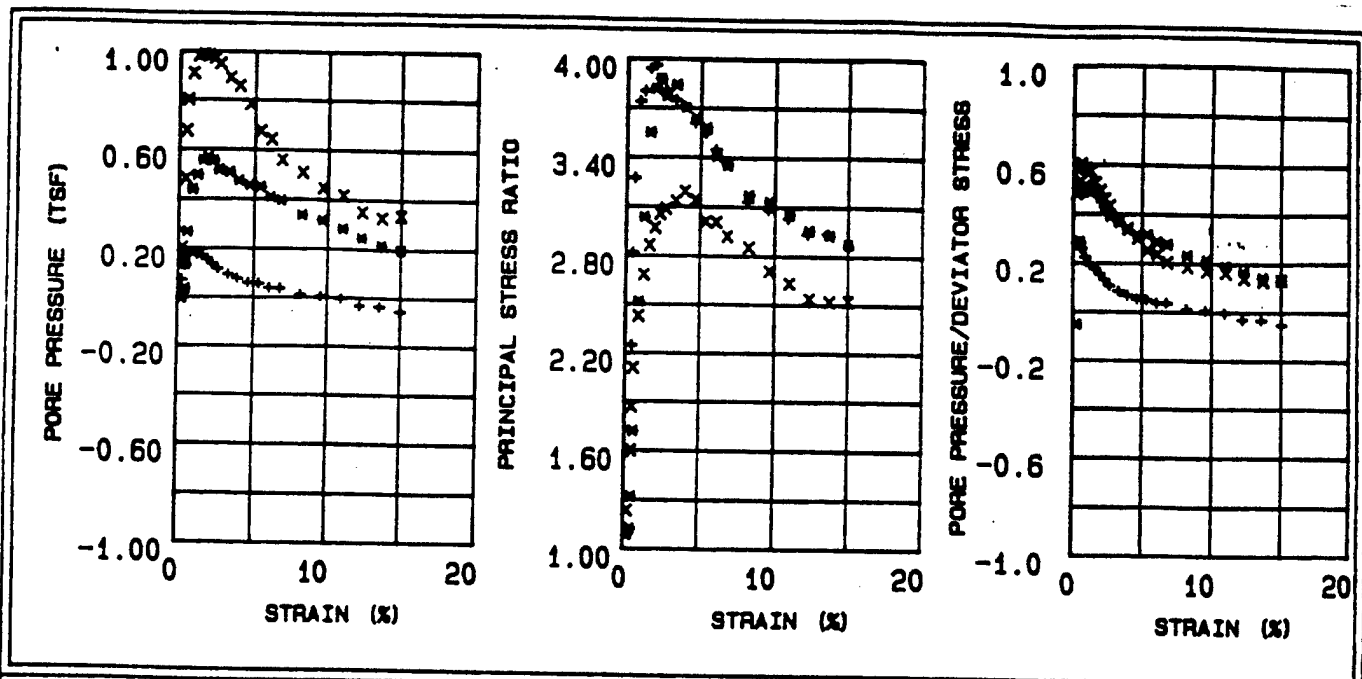
89/177

FIGURE 10

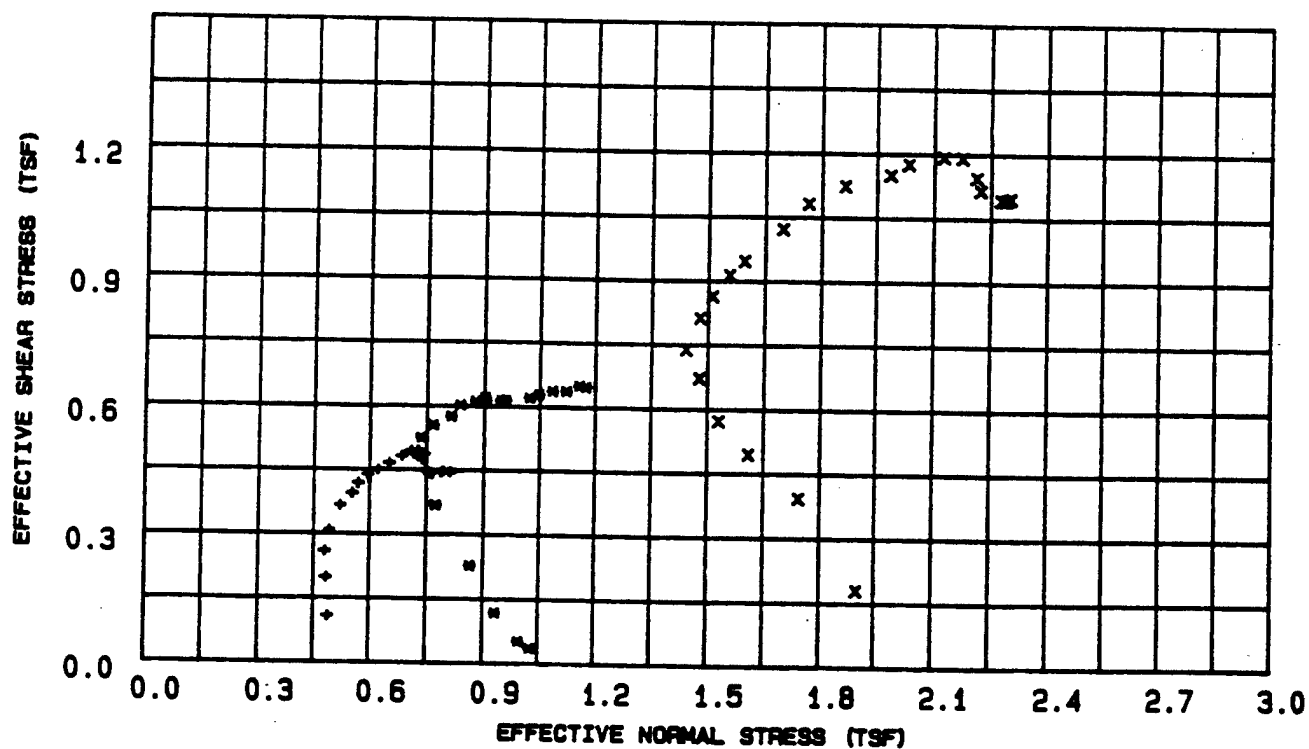








EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



28°

LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

CHASKA: NCS-1A-89-09-ED-0H

BORING NO.

89-102 MU

SAMPLE NO.

5

DEPTH/ELEV

43'-48'

MPD LAB NO.

88/177

FIGURE 17

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-102 MU  
 Sample Number : 5  
 Depth : 43'-45'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.28	0.252	0.072	1.589	0.285	0.490	0.109
30	0.49	0.462	0.130	2.249	0.283	0.484	0.199
45	0.51	0.602	0.169	2.820	0.281	0.480	0.260
60	0.61	0.716	0.185	3.272	0.259	0.492	0.309
90	0.91	0.851	0.189	3.740	0.223	0.522	0.367
120	1.24	0.916	0.173	3.803	0.190	0.554	0.395
150	1.59	0.970	0.170	3.941	0.176	0.570	0.419
180	1.94	1.016	0.157	3.964	0.155	0.595	0.431
210	2.27	1.044	0.137	3.876	0.132	0.622	0.451
240	2.64	1.080	0.116	3.809	0.107	0.651	0.466
300	3.31	1.118	0.093	3.747	0.084	0.684	0.483
360	3.92	1.148	0.076	3.707	0.067	0.708	0.495
420	4.62	<u>1.150</u>	<u>0.059</u>	3.607	0.052	0.726	0.496
480	5.32	1.135	0.055	3.549	0.049	0.726	0.490
540	6.02	1.129	0.038	3.446	0.035	0.741	0.487
600	6.75	1.097	0.036	3.366	0.034	0.736	0.473
720	8.17	1.043	0.011	3.131	0.011	0.747	0.450
840	9.55	1.030	0.004	3.078	0.005	0.751	0.445
960	10.91	1.026	-0.005	3.030	-0.005	0.759	0.443
1080	12.21	1.029	-0.032	2.935	-0.031	0.787	0.444
1200	13.57	1.039	-0.036	2.937	-0.034	0.793	0.444
1316	15.00	1.030	-0.055	2.856	-0.053	0.811	0.445

Table 5 - Triaxial  $\bar{R}$  Test Results

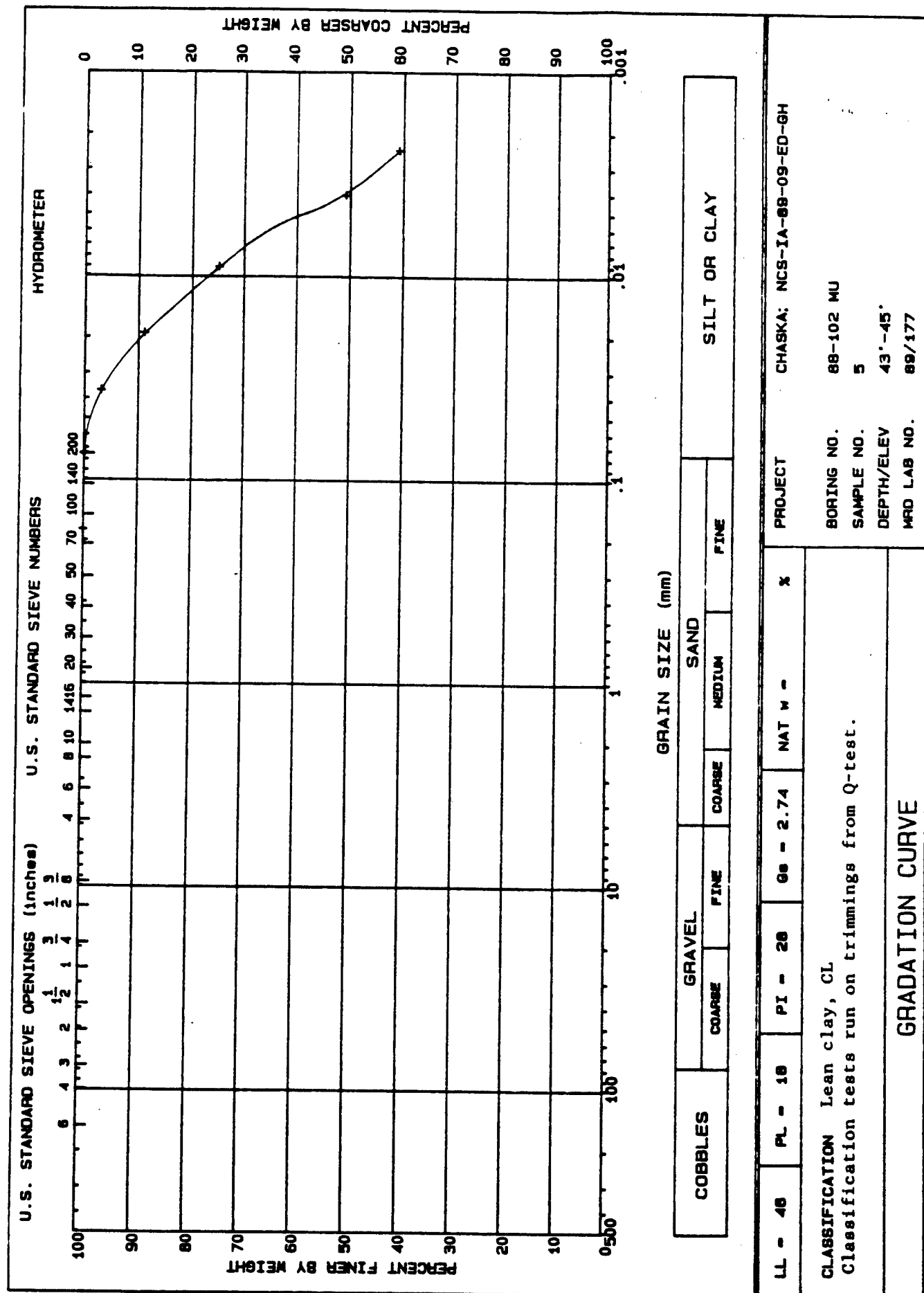
Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-102 MU  
 Sample Number : 5  
 Depth : 43'-45'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.28	0.084	-0.005	1.084	-0.053	1.026	0.036
30	0.49	0.121	0.035	1.125	0.286	0.995	0.052
45	0.52	0.277	0.136	1.320	0.490	0.932	0.119
60	0.61	0.528	0.267	1.720	0.505	0.864	0.228
90	0.92	0.853	0.438	2.519	0.514	0.773	0.368
120	1.25	1.021	0.498	3.036	0.489	0.755	0.441
150	1.60	1.130	0.557	3.551	0.494	0.723	0.488
180	1.95	1.218	0.568	3.818	0.466	0.734	0.526
210	2.29	1.288	0.553	3.878	0.430	0.766	0.556
240	2.66	1.336	0.518	3.772	0.388	0.813	0.577
300	3.34	1.396	0.509	3.843	0.365	0.837	0.603
360	3.96	1.419	0.474	3.700	0.335	0.877	0.613
420	4.66	1.440	0.455	3.640	0.316	0.901	0.621
480	5.37	1.422	0.449	3.580	0.316	0.903	0.614
540	6.07	1.423	0.408	3.405	0.287	0.944	0.614
600	6.81	1.424	0.395	3.352	0.278	0.957	0.615
720	8.24	1.442	0.336	3.171	0.233	1.021	0.622
840	9.63	1.460	0.315	3.131	0.216	1.047	0.630
960	11.00	1.477	0.282	3.056	0.191	1.084	0.638
1080	12.32	1.477	0.245	2.958	0.167	1.121	0.638
1200	13.68	1.508	0.217	2.926	0.144	1.156	0.651
1306	15.00	1.502	0.198	2.873	0.132	1.174	0.648

Table 6 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-102 MU  
 Sample Number : 5  
 Depth : 43'-45'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.28	0.418	0.202	1.233	0.483	1.902	0.180
30	0.49	0.910	0.482	1.599	0.530	1.743	0.393
45	0.52	1.147	0.675	1.866	0.589	1.609	0.495
60	0.61	1.328	0.800	2.107	0.603	1.529	0.573
90	0.92	1.558	0.909	2.428	0.584	1.477	0.672
120	1.25	1.713	0.982	2.683	0.574	1.442	0.739
150	1.60	1.885	0.989	2.864	0.525	1.478	0.813
180	1.96	2.001	0.985	2.972	0.493	1.510	0.813
210	2.29	2.117	0.970	3.056	0.459	1.554	0.914
240	2.67	2.195	0.949	3.088	0.433	1.594	0.947
300	3.35	2.368	0.890	3.134	0.376	1.696	1.022
360	3.96	2.506	0.857	3.193	0.342	1.764	1.082
420	4.67	2.604	0.782	3.138	0.301	1.863	1.124
480	5.38	2.665	0.674	3.009	0.253	1.986	1.150
540	6.09	2.725	0.642	3.006	0.236	2.033	1.176
600	6.82	2.765	0.559	2.918	0.203	2.125	1.193
720	8.26	2.759	0.509	2.850	0.185	2.174	1.191
840	9.65	2.653	0.445	2.707	0.168	2.212	1.145
960	11.02	2.583	0.417	2.632	0.162	2.223	1.115
1080	12.34	2.532	0.350	2.535	0.139	2.277	1.082
1200	13.71	2.542	0.327	2.519	0.129	2.302	1.097
1304	15.00	2.532	0.337	2.522	0.133	2.290	1.093



**COBBLES**

COARSE FINE

**GRAIN SIZE (mm)**

100 60 30 15 7.5 4.75 2.5 1.18 0.6 0.3 0.15 0.075

**LL - 48**

**PL - 18**

**PI - 28**

**Gr - 2.74**

**NAT W -**

**X**

**PROJECT**

CHASKA; NCS-IA-88-09-ED-6H

**CLASSIFICATION**

Lean clay, CL

Classification tests run on trimmings from Q-test.

**GRADATION CURVE**

**BORING NO.**

88-102 MU

**SAMPLE NO.**

5

**DEPTH/ELEV**

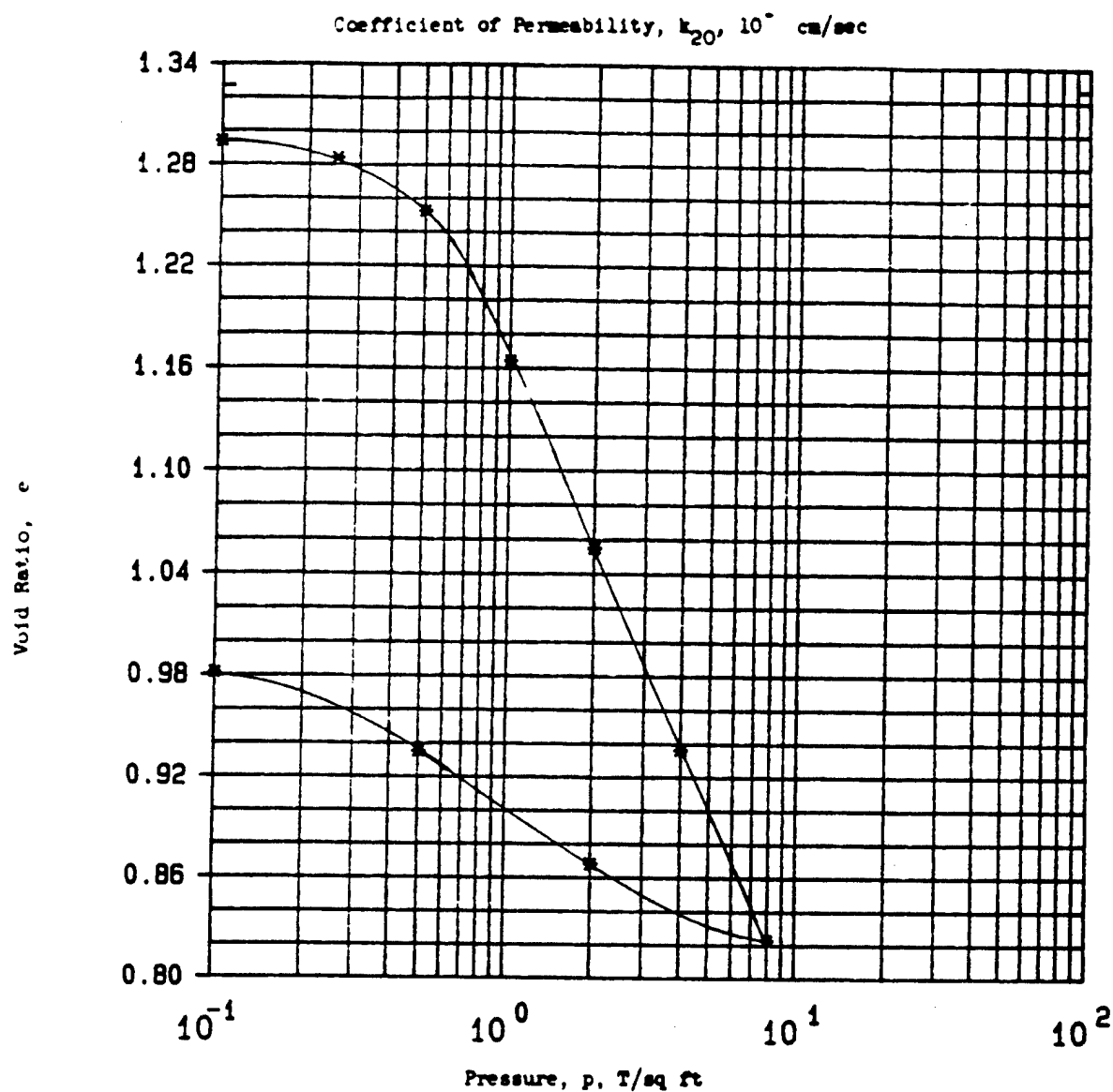
43'-45'

**MRD LAB NO.**

89/177

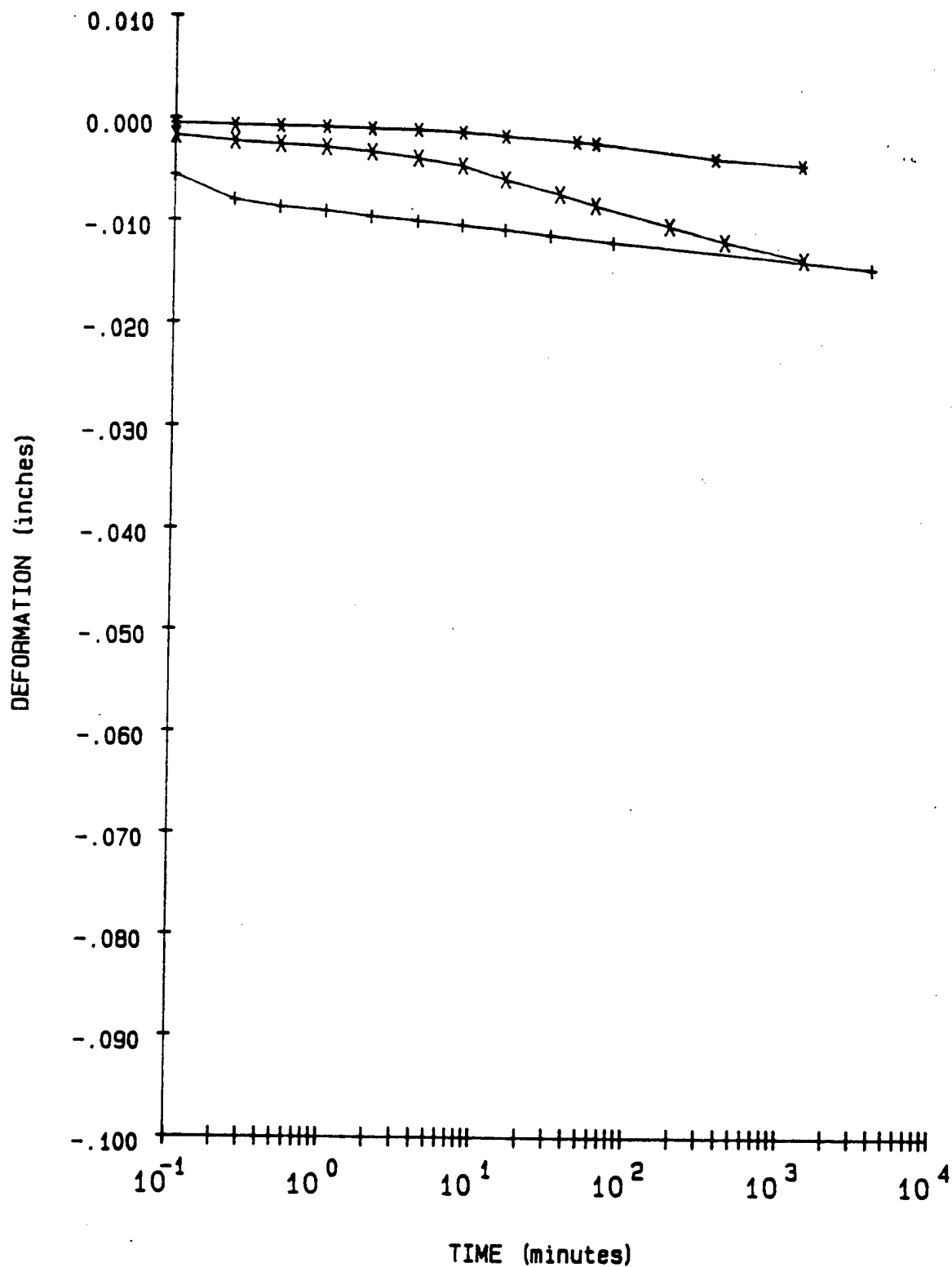
Figure C-251

FIGURE 18



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Rt	1 in.	Water Content, $w_o$	46.9 %	$w_f$	37.3 %
Overburden Pressure, $p_o$			T/sq ft	Void Ratio, $e_o$	1.33	$e_f$	0.98
Preconsol. Pressure, $p_c$			T/sq ft	Saturation, $S_o$	94 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	71.6 lb/ft <sup>3</sup>		
Classification Fat clay, CH				$k_{20}$ at $e_o$ = $\times 10^{-8}$ cm/sec			
LL	69	$G_s$	2.67	Project CHASKA; NCS-IA-89-09-ED-6H			
PL	24	$D_{10}$					
Remarks Gray with rust spots, non-calcareous. Torvane=0.4 TSF.				Area MRD LAB NO. 89/177			
				Boring No. 88-103 MU		Sample No. 1	
				Depth El 6'-8'		Date	
				CONSOLIDATION TEST REPORT			





LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 X = .5 TSF

PROJECT

CHASKA; NCS-IA-89-09-ED-6H

BORING NO.

89-103 MU

SAMPLE NO.

1

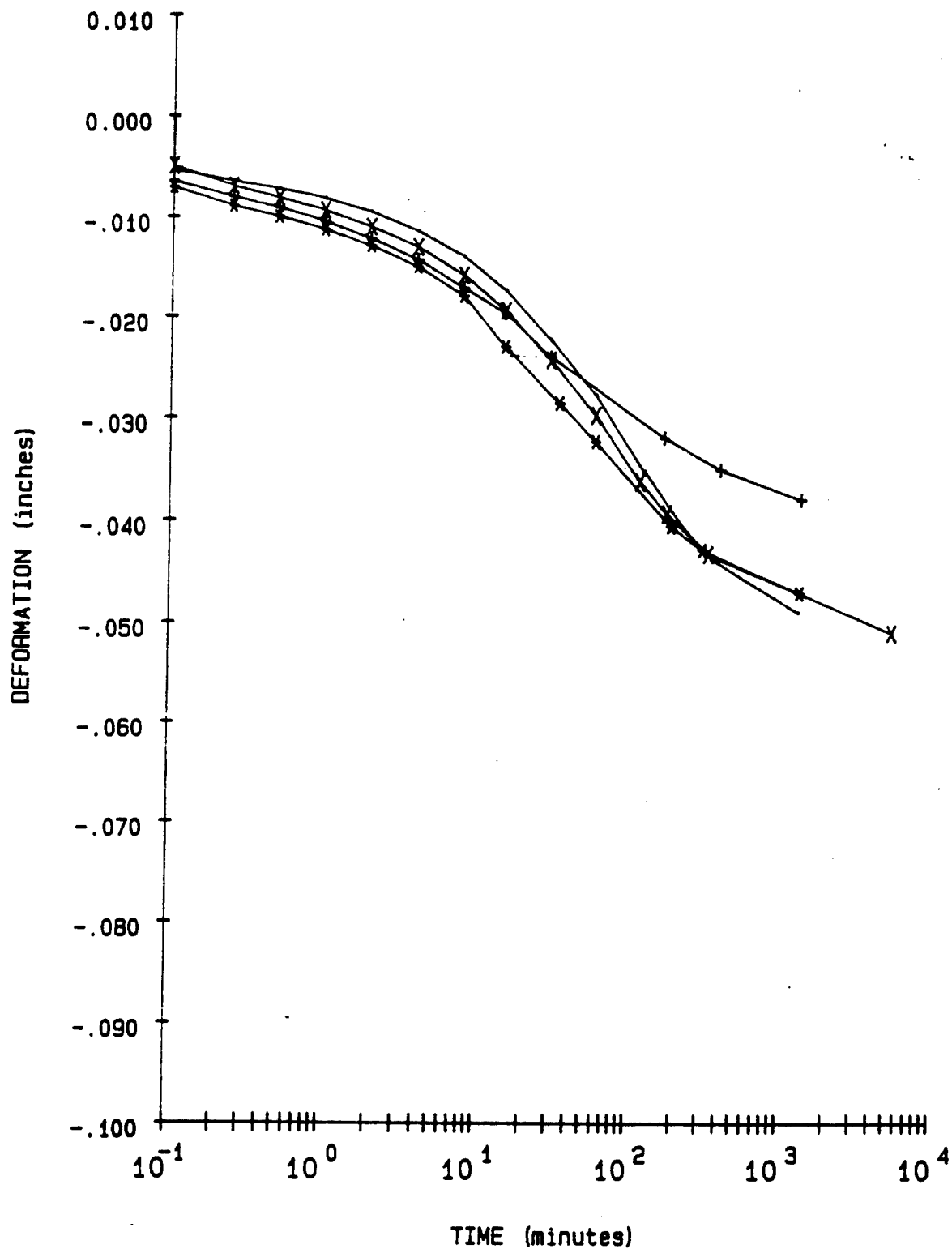
DEPTH/ELEV

6'-8'

MWD LAB NO.

89/177

FIGURE 20



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 X = 4 TSF  
 - = 8 TSF

PROJECT

CHASKA: NCS-1A-89-09-ED-8H

BORING NO.

88-103 MU

SAMPLE NO.

1

DEPTH/ELEV

6'-8'

MRD LAB NO.

89/177

FIGURE 21

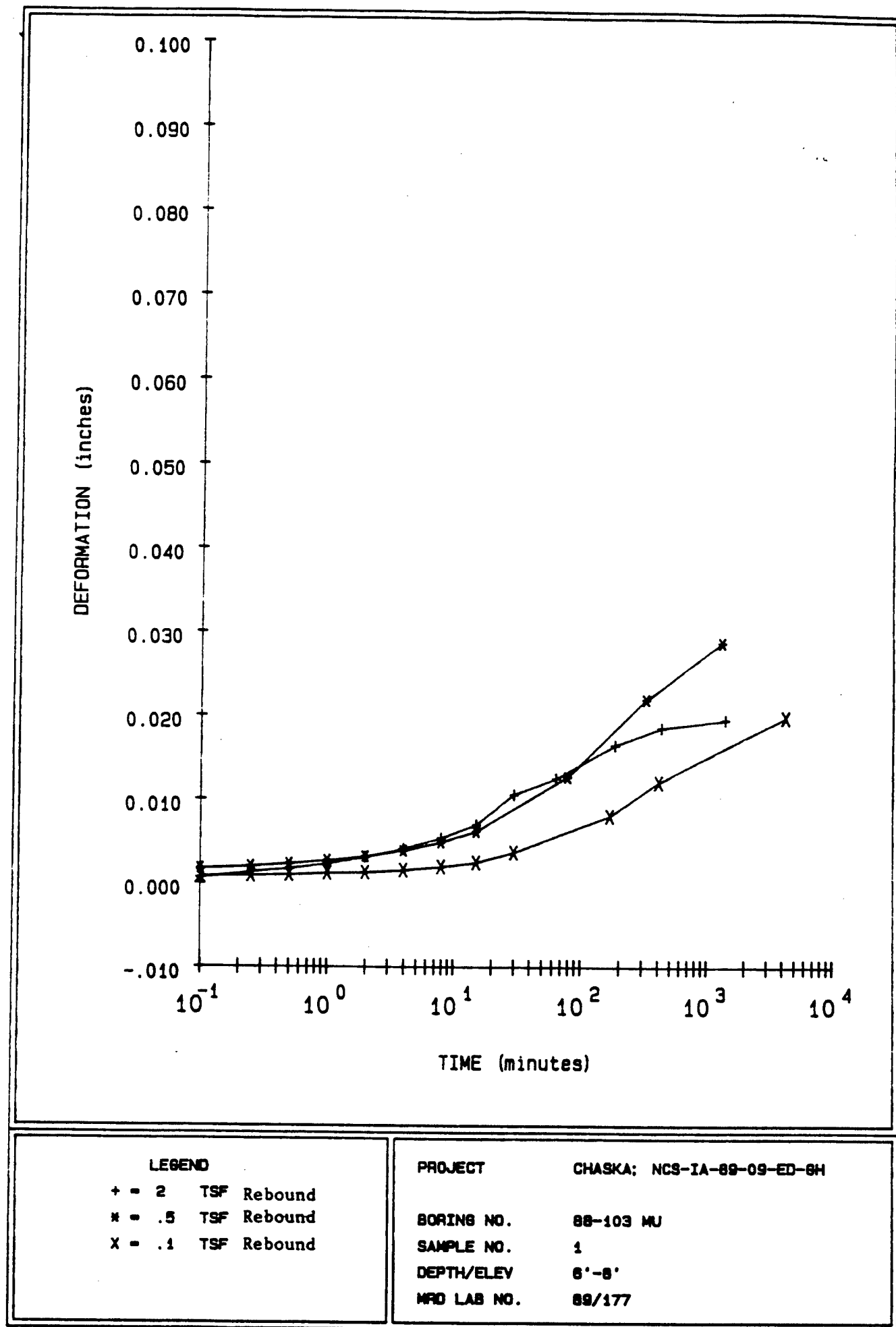
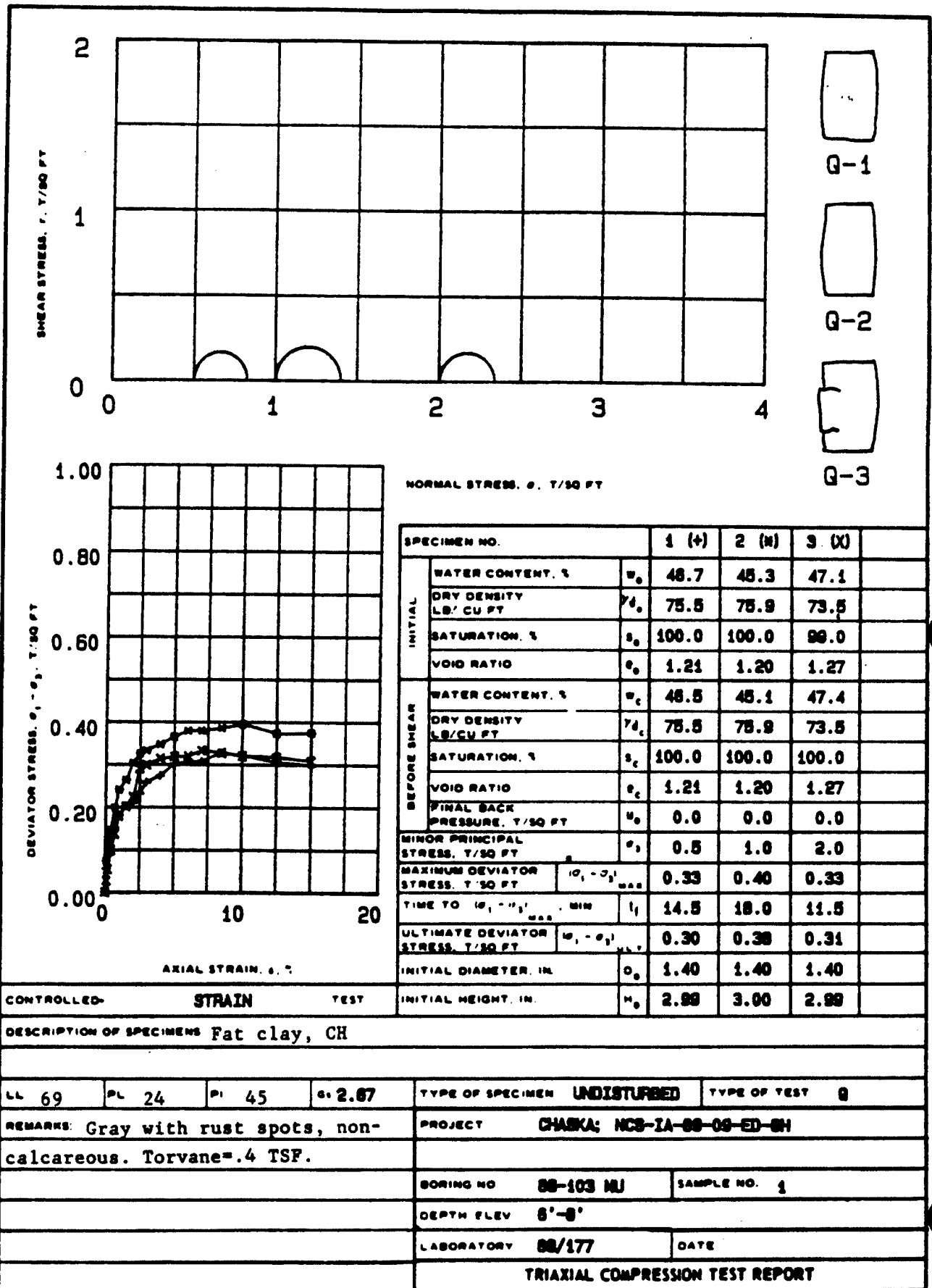
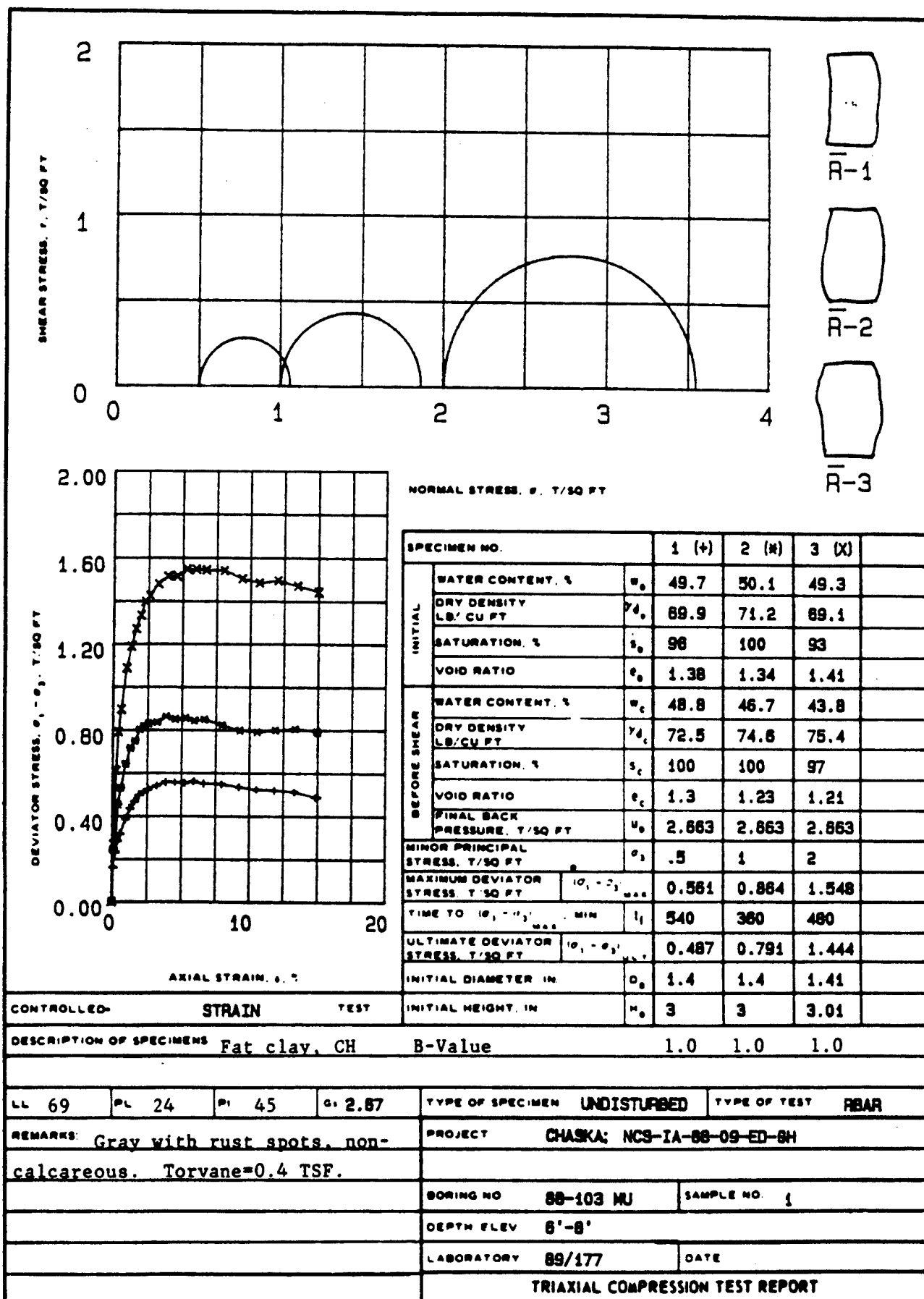
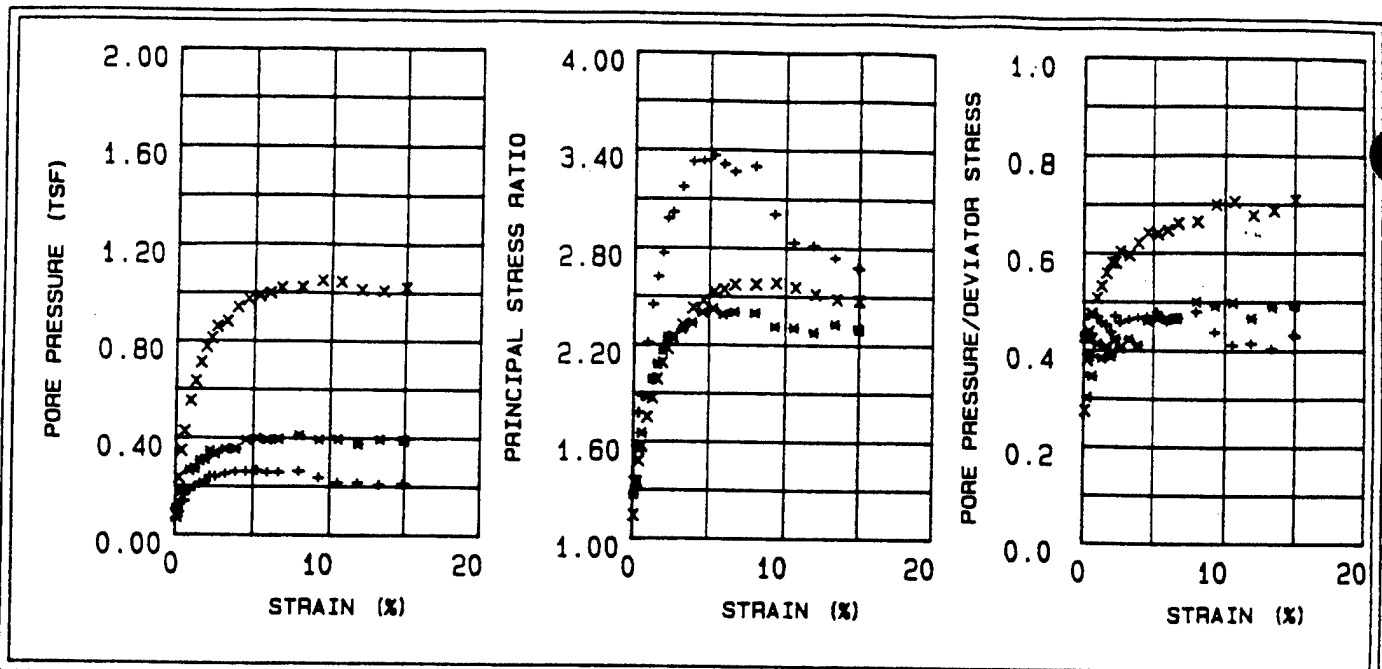


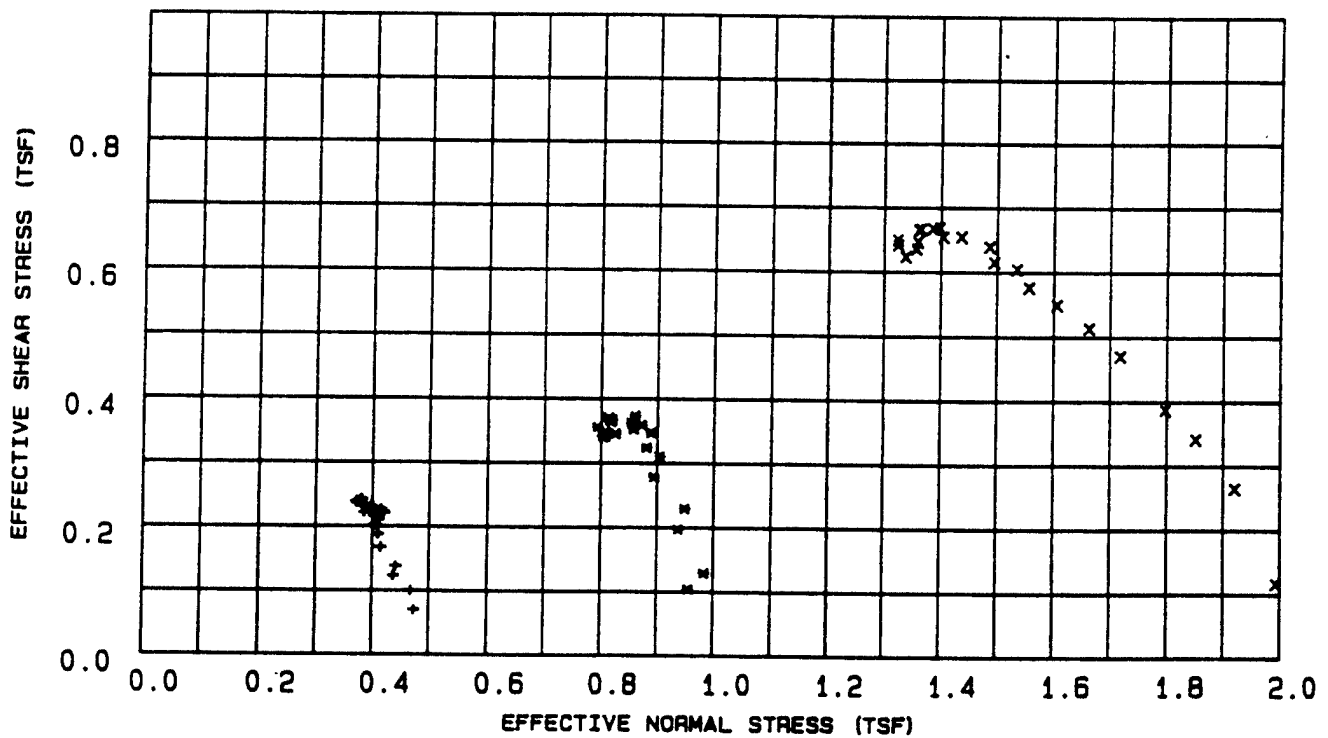
FIGURE 22







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

CHASKA; NCS-1A-88-09-ED-GH

BORING NO.

88-103 MU

SAMPLE NO.

1

DEPTH/ELEV

6'-8'

MRD LAB NO.

89/177

Table 7 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-88-09-ED-GH  
 Boring Number : 88-103 MU  
 Sample Number : 1  
 Depth : 6'-8'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.162	0.067	1.374	0.416	0.473	0.070
30	0.26	0.232	0.091	1.568	0.390	0.467	0.100
45	0.40	0.285	0.134	1.780	0.472	0.437	0.123
60	0.59	0.319	0.138	1.880	0.432	0.441	0.138
90	0.95	0.387	0.181	2.213	0.469	0.415	0.167
120	1.26	0.437	0.198	2.447	0.455	0.410	0.188
150	1.59	0.468	0.211	2.619	0.452	0.405	0.202
180	1.92	0.499	0.218	2.766	0.437	0.405	0.215
210	2.23	0.512	0.241	2.977	0.471	0.386	0.221
240	2.57	0.525	0.240	3.019	0.457	0.390	0.227
300	3.21	0.542	0.251	3.173	0.463	0.383	0.234
360	3.87	0.558	0.260	3.328	0.467	0.378	0.241
420	4.54	0.557	0.261	3.332	0.470	0.377	0.240
480	5.25	0.554	0.266	3.365	0.479	0.371	0.239
540	5.91	<u>0.561</u>	<u>0.257</u>	3.310	0.458	0.382	0.242
600	6.62	0.550	0.257	3.265	0.467	0.379	0.238
720	7.96	0.547	0.262	3.299	0.480	0.373	0.236
840	9.26	0.534	0.234	3.006	0.437	0.398	0.231
960	10.54	0.523	0.214	2.830	0.411	0.415	0.226
1080	11.87	0.518	0.214	2.813	0.414	0.414	0.224
1200	13.32	0.511	0.206	2.737	0.403	0.421	0.221
1320	14.87	0.487	0.210	2.679	0.432	0.410	0.210
1330	15.00	0.487	0.209	2.671	0.429	0.411	0.210

Table 8 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-88-09-ED-GH  
 Boring Number : 88-103 MU  
 Sample Number : 1  
 Depth : 6'-8'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.242	0.104	1.269	0.429	0.956	0.104
30	0.26	0.293	0.090	1.328	0.301	0.984	0.129
45	0.40	0.455	0.176	1.553	0.387	0.937	0.197
60	0.60	0.532	0.183	1.651	0.345	0.949	0.229
90	0.95	0.644	0.266	1.878	0.413	0.894	0.278
120	1.26	0.718	0.274	1.989	0.383	0.904	0.310
150	1.60	0.751	0.306	2.082	0.407	0.880	0.324
180	1.93	0.804	0.311	2.166	0.387	0.888	0.337
210	2.24	0.818	0.345	2.249	0.423	0.857	0.353
240	2.57	0.831	0.335	2.249	0.404	0.871	0.359
300	3.22	0.838	0.354	2.297	0.423	0.853	0.362
360	3.88	0.864	0.354	2.337	0.410	0.860	0.373
420	4.55	0.851	0.392	2.400	0.461	0.819	0.367
480	5.27	0.856	0.399	2.424	0.466	0.813	0.370
540	5.93	0.844	0.392	2.387	0.465	0.817	0.364
600	6.65	0.849	0.395	2.403	0.466	0.815	0.366
720	7.98	0.823	0.411	2.397	0.500	0.793	0.355
840	9.29	0.798	0.392	2.312	0.492	0.805	0.344
960	10.58	0.791	0.394	2.304	0.498	0.802	0.341
1080	11.91	0.800	0.373	2.276	0.466	0.825	0.337
1200	13.37	0.806	0.394	2.330	0.489	0.806	0.348
1320	14.92	0.793	0.390	2.300	0.493	0.806	0.342
1326	15.00	0.791	0.390	2.296	0.493	0.806	0.341



Table 9 - Triaxial R Test Results

Project : CHASKA; NCS-IA-88-09-ED-GH  
 Boring Number : 88-103 MU  
 Sample Number : 1  
 Depth : 6'-8'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.269	0.074	1.140	0.274	1.993	0.116
30	0.26	0.612	0.232	1.346	0.379	1.920	0.264
45	0.41	0.791	0.345	1.478	0.437	1.851	0.341
60	0.60	0.896	0.425	1.569	0.474	1.797	0.387
90	0.96	1.088	0.551	1.751	0.507	1.718	0.470
120	1.27	1.189	0.632	1.869	0.532	1.662	0.513
150	1.61	1.271	0.710	1.986	0.559	1.605	0.549
180	1.95	1.335	0.774	2.089	0.581	1.557	0.576
210	2.26	1.399	0.811	2.177	0.581	1.535	0.604
240	2.60	1.426	0.859	2.249	0.603	1.494	0.615
300	3.25	1.480	0.880	2.322	0.595	1.486	0.639
360	3.92	1.515	0.939	2.428	0.620	1.436	0.654
420	4.60	1.515	0.971	2.472	0.641	1.404	0.654
480	5.32	1.548	0.986	2.526	0.638	1.397	0.668
540	5.99	1.547	0.998	2.544	0.646	1.385	0.667
600	6.71	1.544	1.018	2.573	0.660	1.364	0.666
720	8.06	1.541	1.021	2.574	0.663	1.360	0.665
840	9.38	1.504	1.049	2.582	0.698	1.323	0.649
960	10.68	1.485	1.044	2.554	0.704	1.324	0.641
1080	12.03	1.496	1.011	2.512	0.676	1.359	0.646
1200	13.50	1.471	1.008	2.482	0.686	1.356	0.635
1315	15.00	1.444	1.021	2.474	0.708	1.337	0.623
1315	15.00	1.444	1.021	2.474	0.708	1.337	0.623

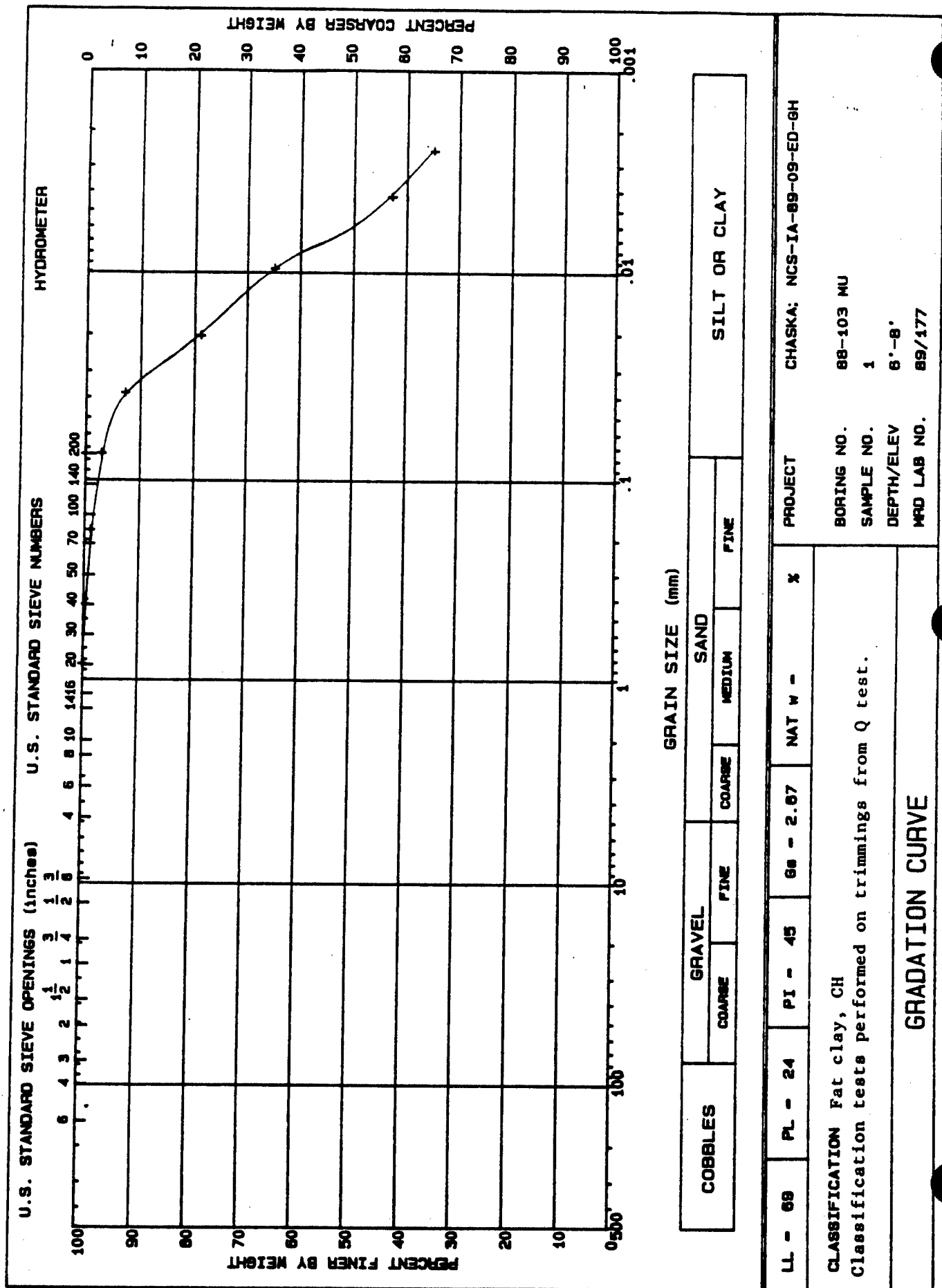
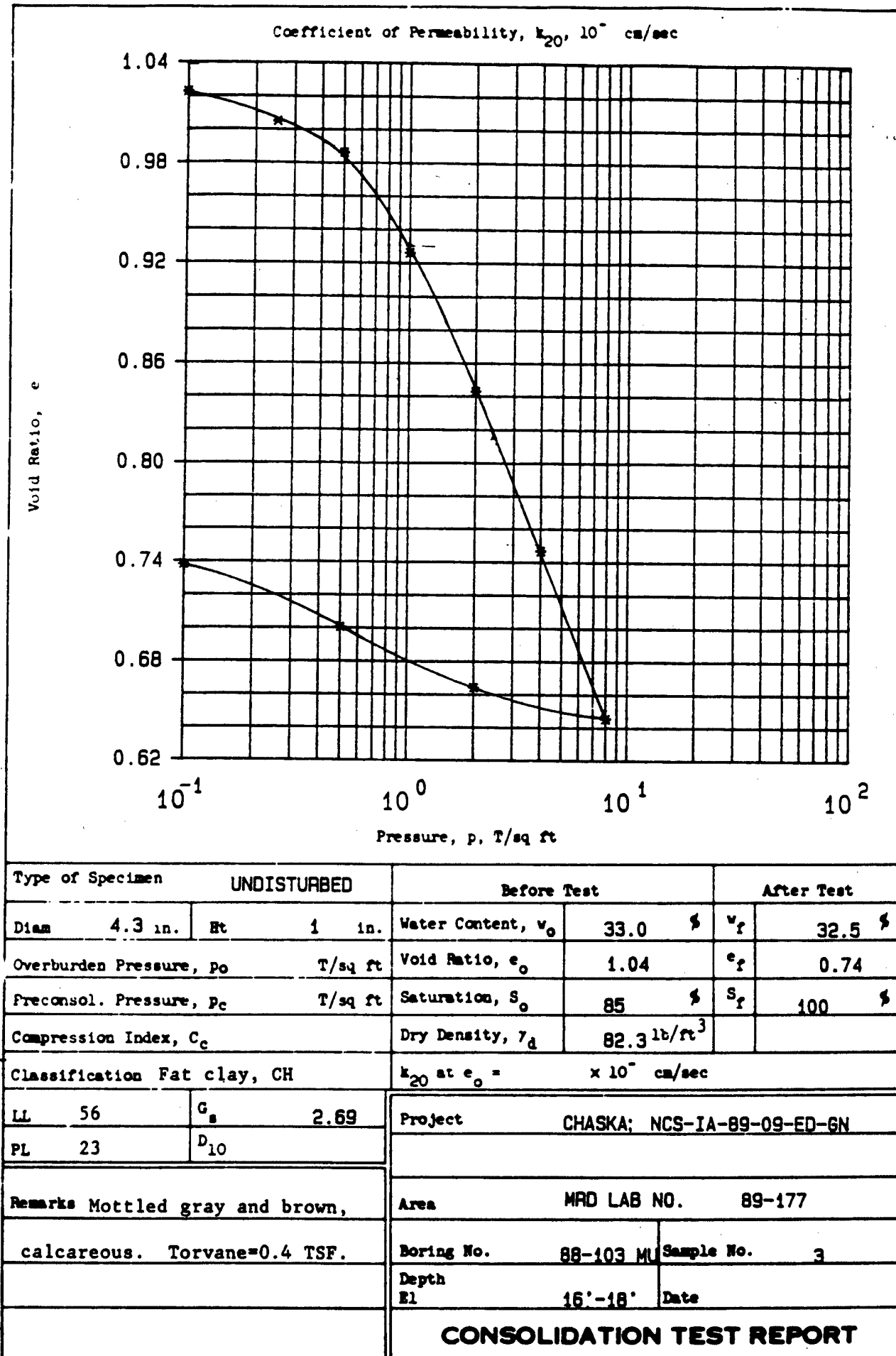


Figure C-262



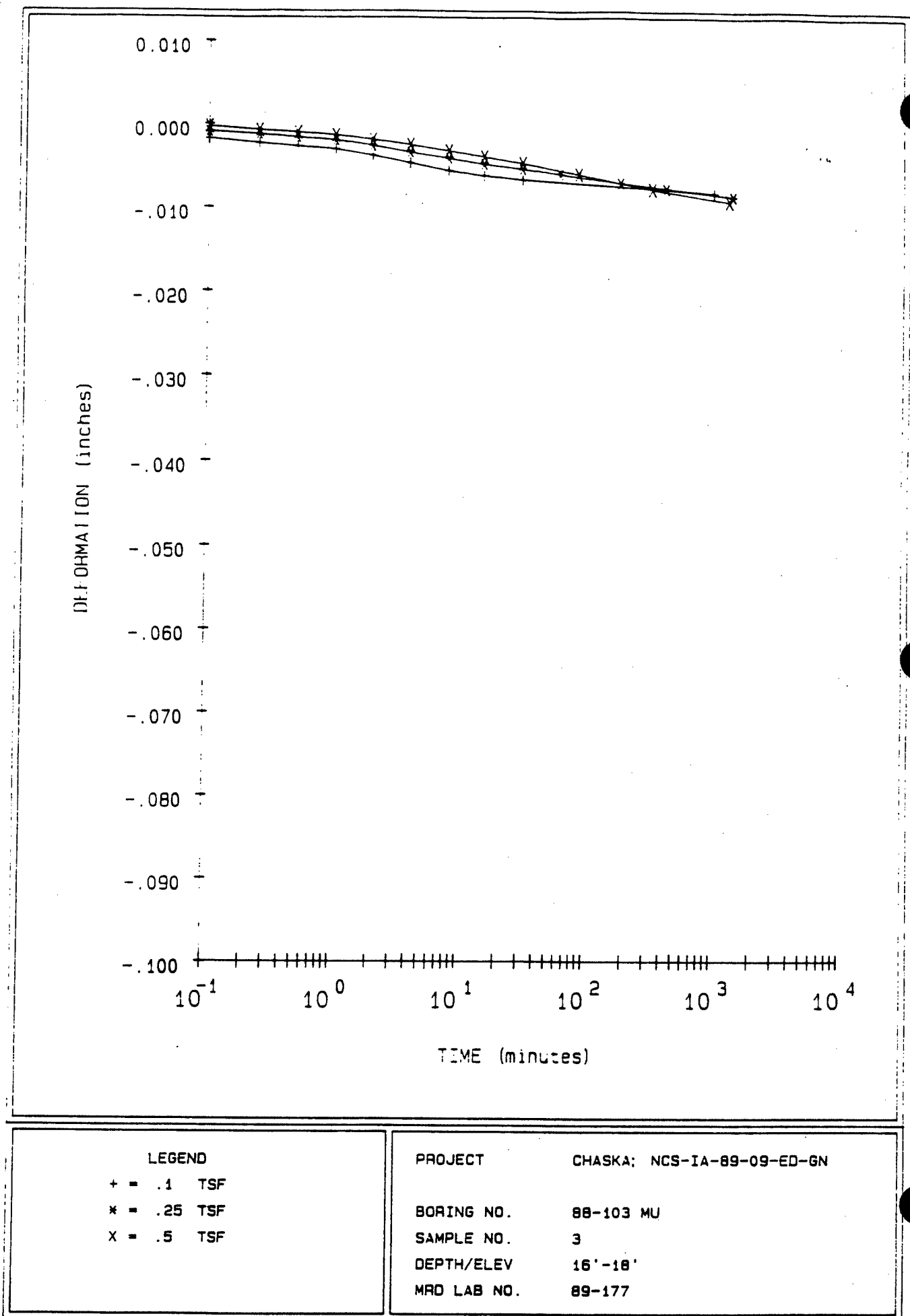
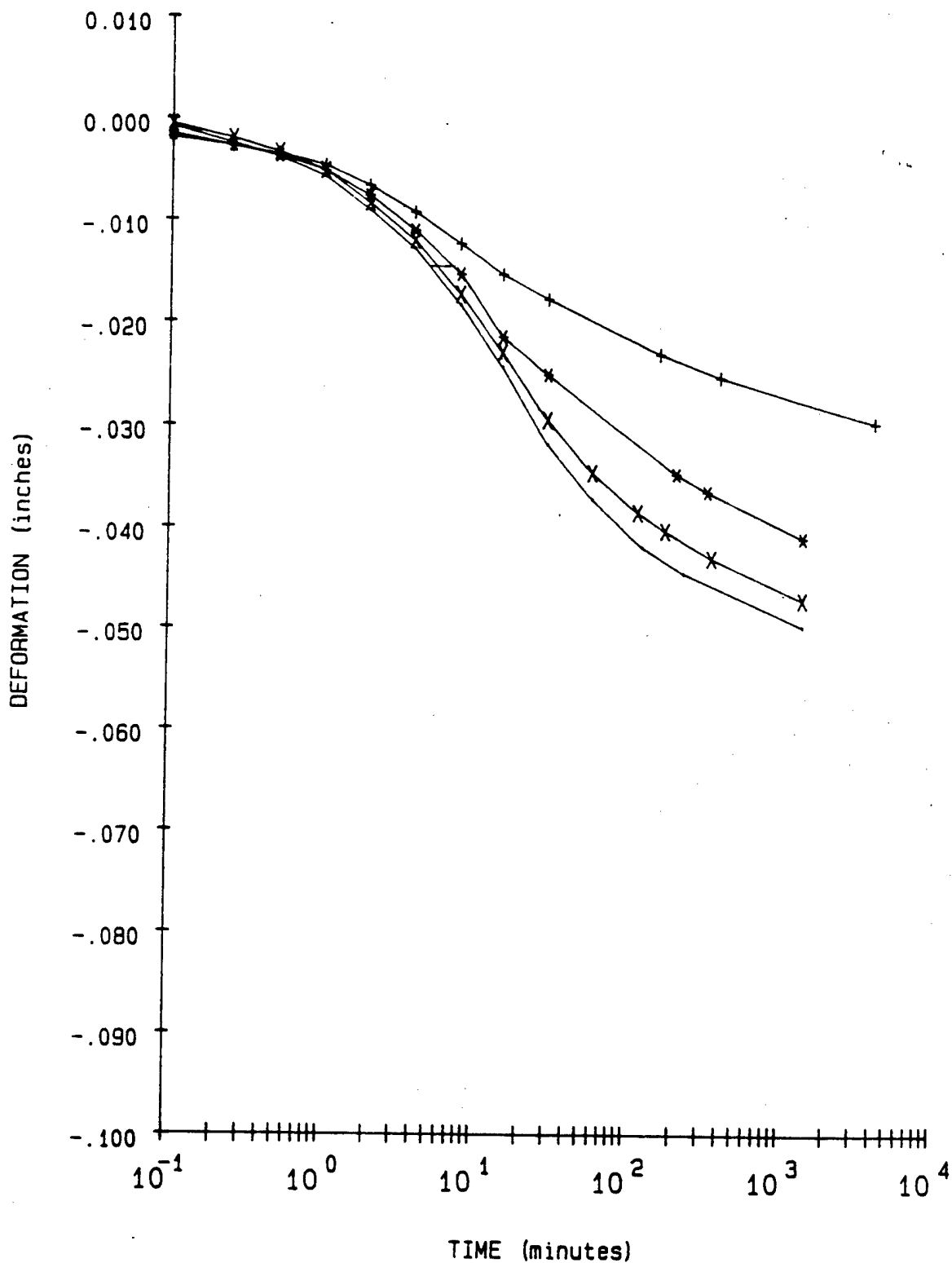


FIGURE 14



LEGEND

- + = 1 TSF
- \* = 2 TSF
- X = 4 TSF
- = 8 TSF

PROJECT

CHASKA; NCS-IA-89-09-ED-GN

BORING NO.

88-103 MU

SAMPLE NO.

3

DEPTH/ELEV

16'-18'

MRD LAB NO.

89-177

FIGURE 15

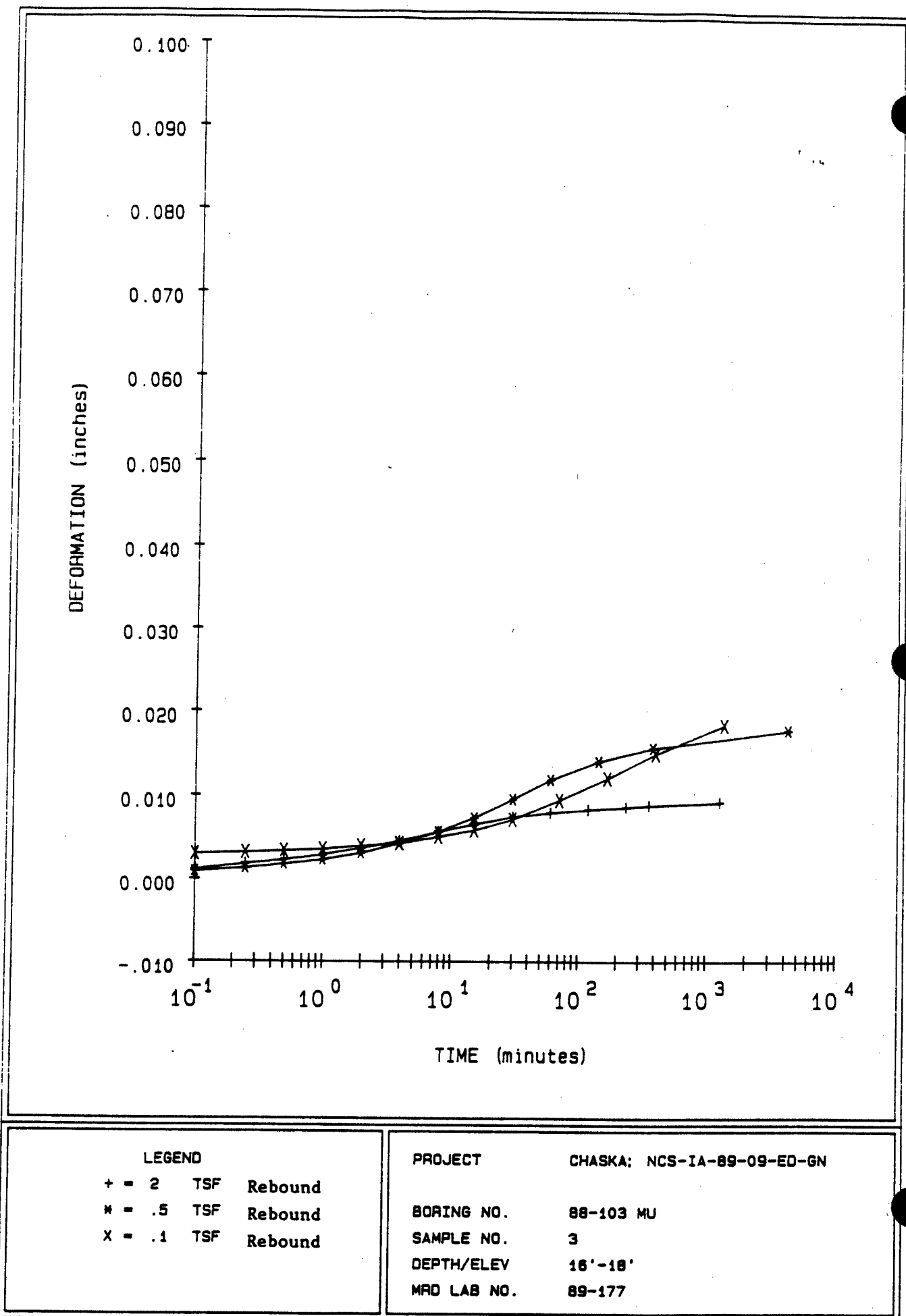
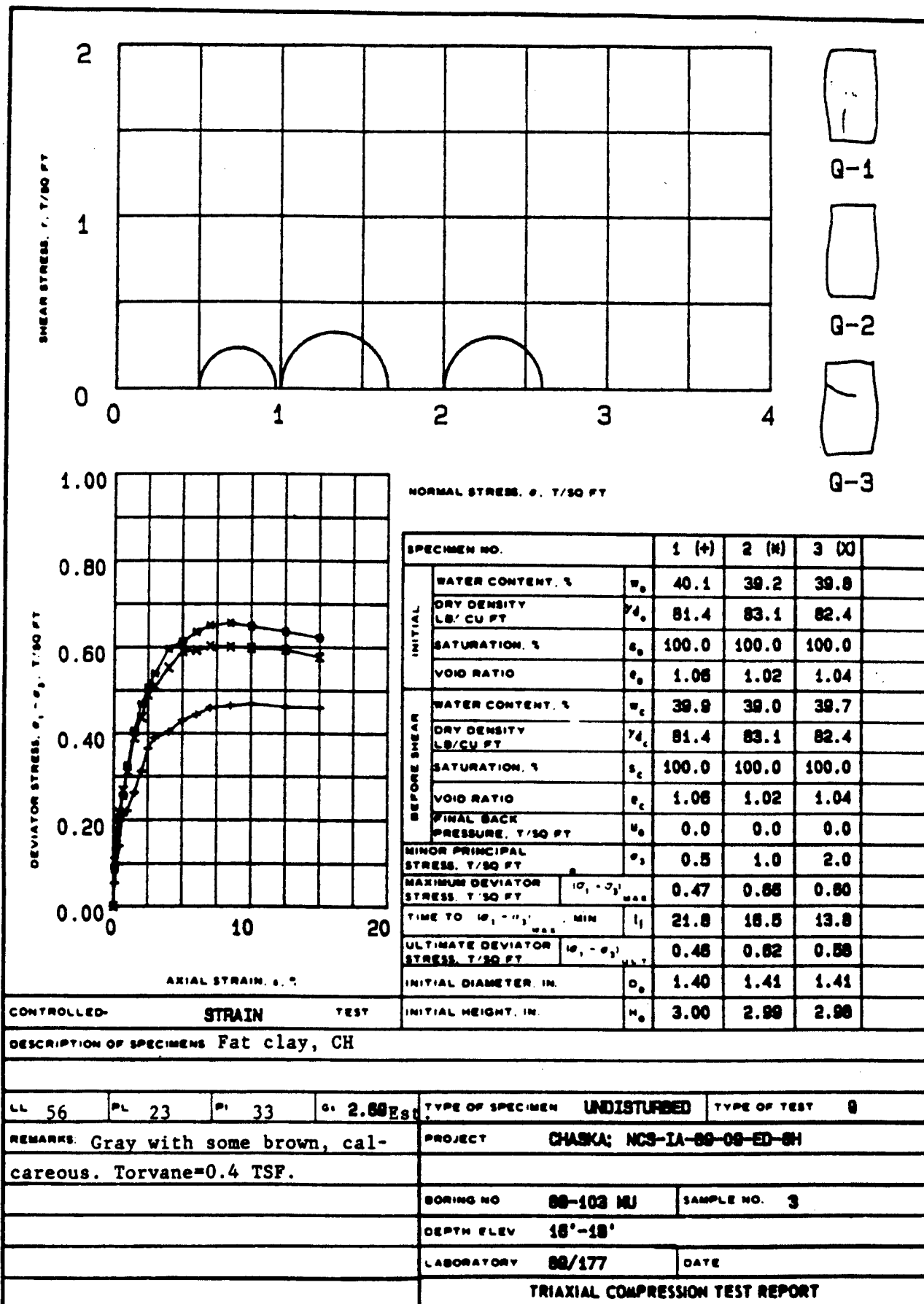
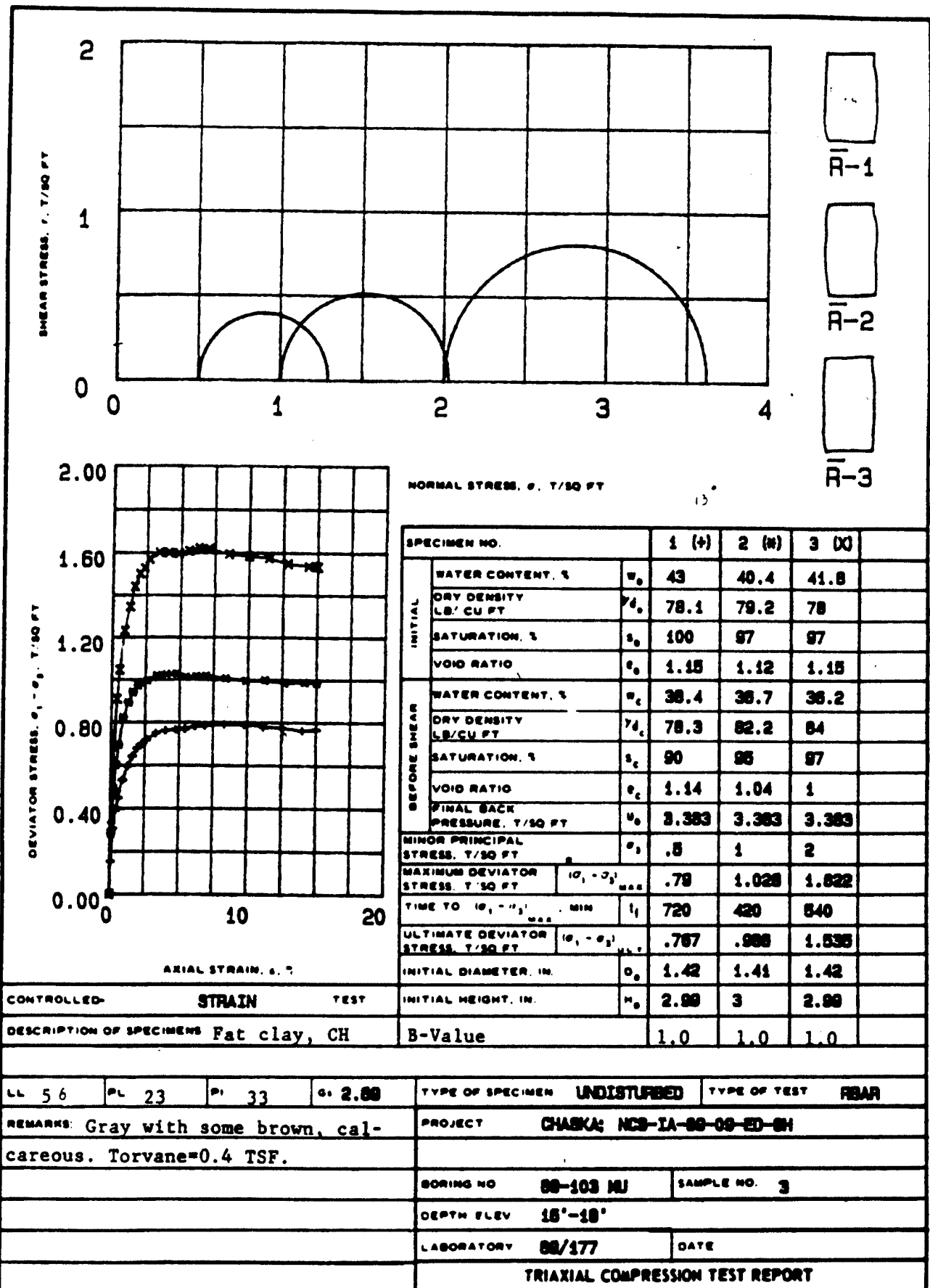
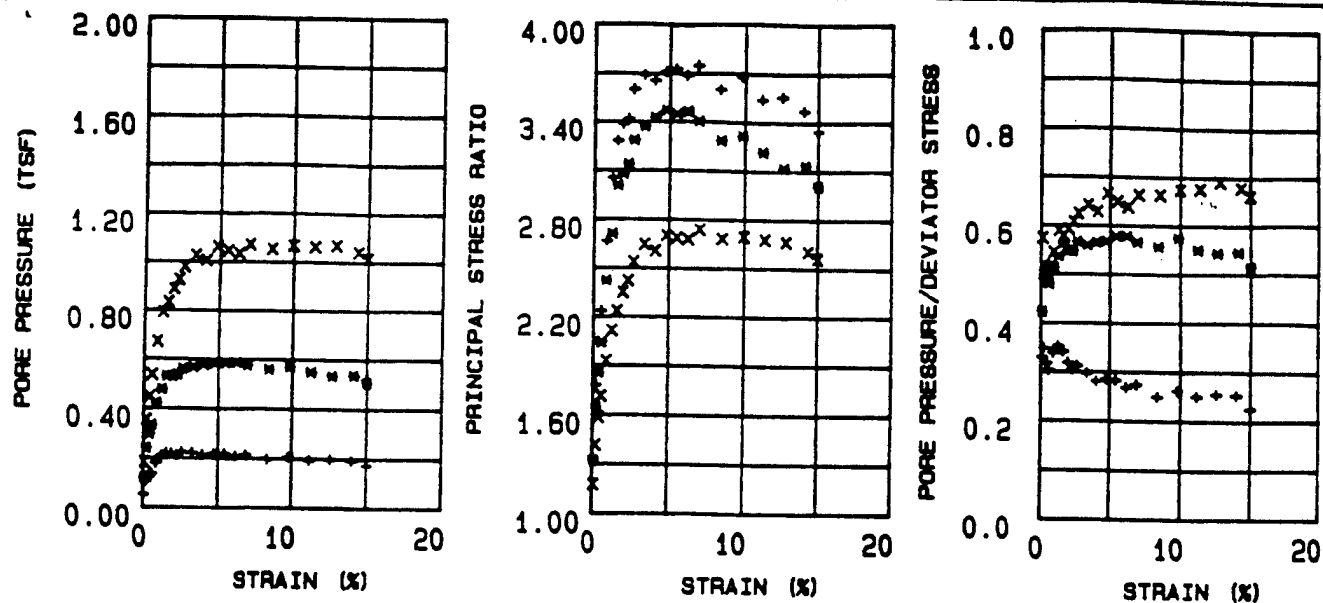


FIGURE 16

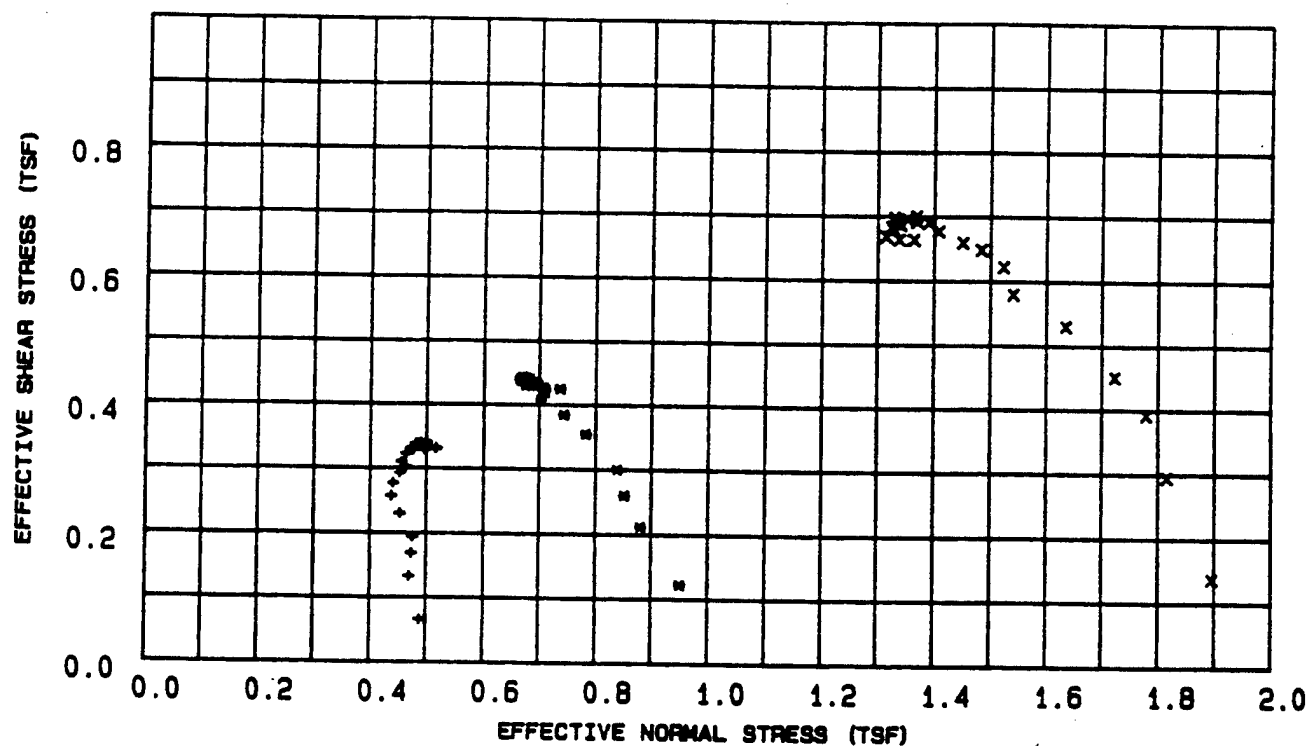








EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

CHASKA; NCS-IA-89-09-ED-6H

BORING NO.

88-103 MU

SAMPLE NO.

3

DEPTH/ELEV

16'-18'

MWD LAB NO.

89/177

FIGURE 27

Table 7 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-103 MU  
 Sample Number : 3  
 Depth : 16'-18'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.153	0.050	1.339	0.329	0.488	0.066
30	0.23	0.307	0.107	1.781	0.348	0.469	0.133
45	0.42	0.392	0.124	2.041	0.317	0.473	0.169
60	0.59	0.450	0.136	2.235	0.302	0.475	0.194
90	0.90	0.532	0.180	2.664	0.339	0.452	0.230
120	1.25	0.596	0.210	3.055	0.353	0.437	0.257
150	1.58	0.642	0.219	3.282	0.341	0.440	0.277
180	1.93	0.679	0.216	3.386	0.318	0.452	0.293
210	2.26	0.699	0.211	3.421	0.303	0.462	0.302
240	2.62	0.718	0.224	3.604	0.312	0.454	0.310
300	3.32	0.749	0.222	3.692	0.297	0.463	0.323
360	4.01	0.762	0.213	3.658	0.281	0.476	0.329
420	4.71	0.766	0.218	3.713	0.285	0.472	0.331
480	5.42	0.770	0.218	3.728	0.283	0.473	0.332
540	6.15	0.782	0.209	3.687	0.268	0.485	0.337
600	6.88	0.785	0.214	3.748	0.274	0.480	0.339
720	8.34	0.790	0.196	3.602	0.249	0.500	0.341
840	9.76	0.788	0.206	3.679	0.262	0.489	0.340
960	11.15	0.778	0.194	3.542	0.250	0.498	0.336
1080	12.54	0.774	0.197	3.559	0.255	0.495	0.335
1200	14.00	0.762	0.192	3.474	0.253	0.497	0.329
1277	15.00	0.767	0.173	3.348	0.226	0.517	0.331

Table 8 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-103 MU  
 Sample Number : 3  
 Depth : 16'-18'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.282	0.119	1.320	0.423	0.951	0.122
30	0.24	0.491	0.240	1.645	0.490	0.881	0.212
45	0.43	0.602	0.297	1.856	0.493	0.852	0.260
60	0.59	0.695	0.333	2.042	0.480	0.839	0.300
90	0.90	0.822	0.422	2.422	0.513	0.782	0.355
120	1.26	0.892	0.478	2.710	0.537	0.743	0.385
150	1.59	0.942	0.531	3.008	0.564	0.702	0.407
180	1.95	0.973	0.532	3.080	0.548	0.709	0.420
210	2.28	0.985	0.540	3.140	0.548	0.704	0.425
240	2.64	0.997	0.564	3.288	0.567	0.683	0.430
300	3.35	1.020	0.570	3.372	0.560	0.682	0.440
360	4.04	1.024	0.579	3.432	0.566	0.675	0.442
420	4.76	<u>1.028</u>	<u>0.585</u>	3.475	0.569	0.669	0.444
480	5.47	1.013	0.586	3.448	0.579	0.665	0.437
540	6.21	1.016	0.588	3.464	0.579	0.664	0.439
600	6.95	1.019	0.576	3.403	0.566	0.676	0.440
720	8.42	1.006	0.560	3.286	0.557	0.689	0.434
840	9.84	0.994	0.572	3.319	0.576	0.674	0.429
960	11.25	0.998	0.550	3.217	0.551	0.697	0.431
1080	12.65	0.985	0.535	3.120	0.544	0.709	0.425
1200	14.13	0.987	0.538	3.136	0.546	0.706	0.426
1266	15.00	0.986	0.507	3.008	0.515	0.737	0.425

Table 9 - Triaxial  $\bar{R}$  Test Results

Project : CHASKA; NCS-IA-89-09-ED-GH  
 Boring Number : 88-103 MU  
 Sample Number : 3  
 Depth : 16'-18'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.317	0.182	1.174	0.574	1.896	0.137
30	0.24	0.684	0.353	1.415	0.517	1.816	0.295
45	0.43	0.909	0.446	1.585	0.491	1.779	0.392
60	0.60	1.046	0.536	1.714	0.513	1.723	0.451
90	0.92	1.231	0.671	1.926	0.545	1.634	0.531
120	1.28	1.345	0.792	2.113	0.589	1.541	0.580
150	1.62	1.441	0.834	2.236	0.579	1.523	0.622
180	1.98	1.501	0.889	2.351	0.593	1.483	0.648
210	2.31	1.527	0.928	2.424	0.608	1.450	0.659
240	2.68	1.569	0.980	2.538	0.625	1.408	0.677
300	3.40	1.601	1.027	2.646	0.642	1.369	0.691
360	4.10	1.599	1.006	2.607	0.629	1.390	0.690
420	4.82	1.596	1.063	2.702	0.666	1.332	0.689
480	5.55	1.609	1.046	2.687	0.650	1.352	0.695
540	6.29	<u>1.622</u>	<u>1.034</u>	2.679	0.638	1.368	0.700
600	7.04	1.617	1.071	2.741	0.663	1.329	0.698
720	8.54	1.592	1.054	2.683	0.663	1.340	0.687
840	9.98	1.583	1.068	2.698	0.675	1.324	0.683
960	11.41	1.574	1.063	2.679	0.676	1.327	0.679
1080	12.83	1.548	1.069	2.664	0.691	1.314	0.668
1200	14.33	1.536	1.042	2.604	0.679	1.338	0.663
1250	15.00	1.535	1.016	2.562	0.662	1.364	0.663

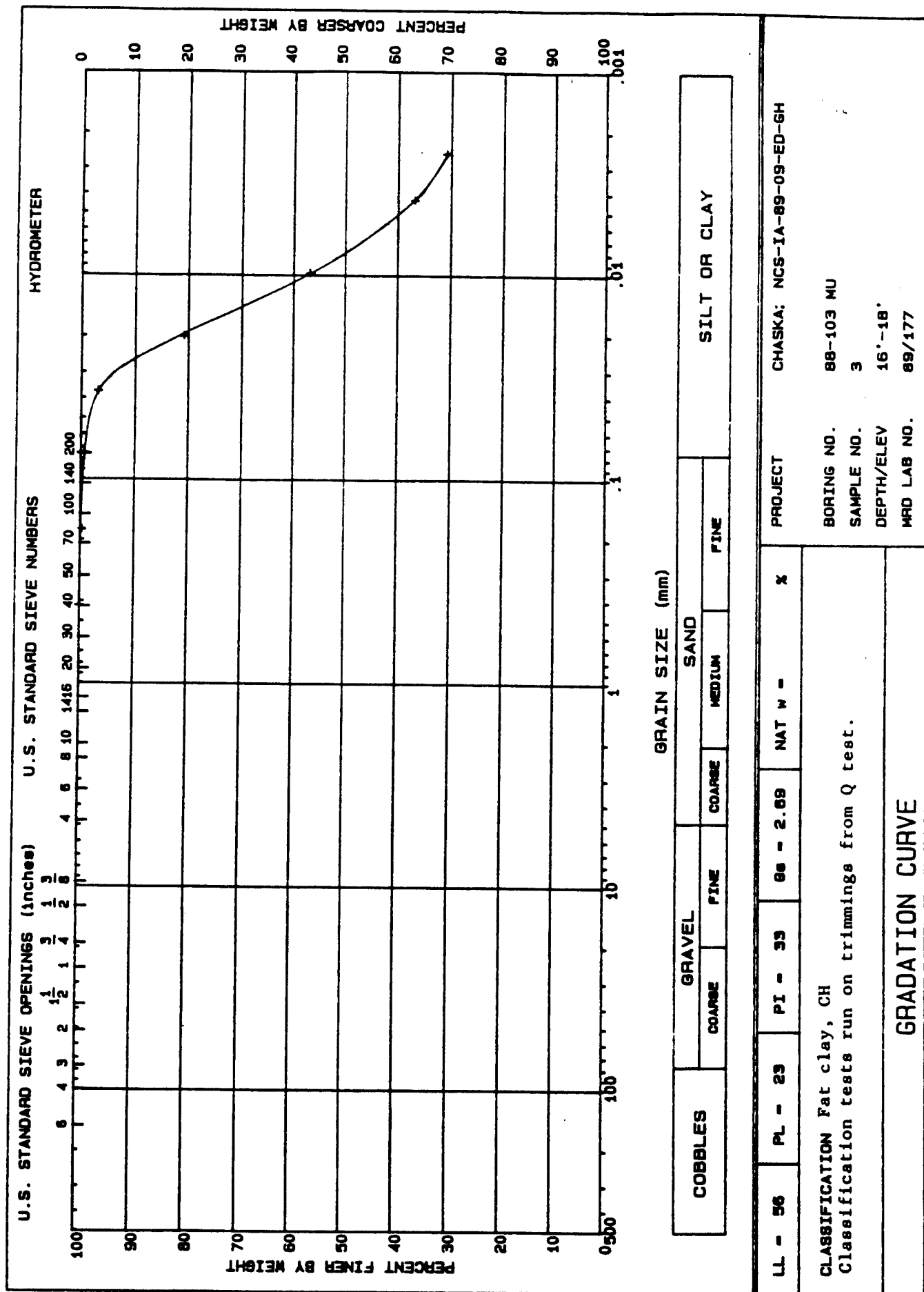
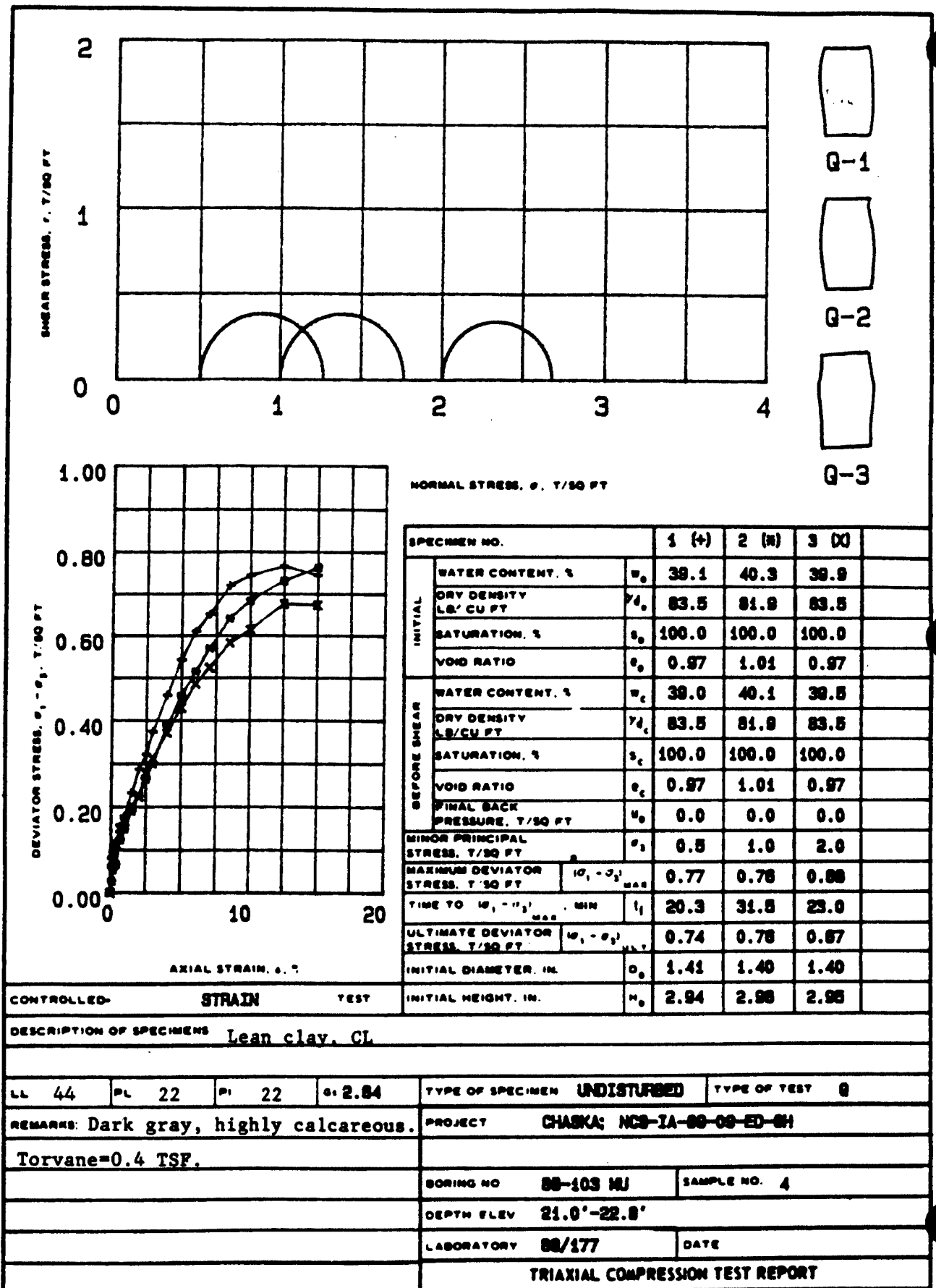


Figure C-273



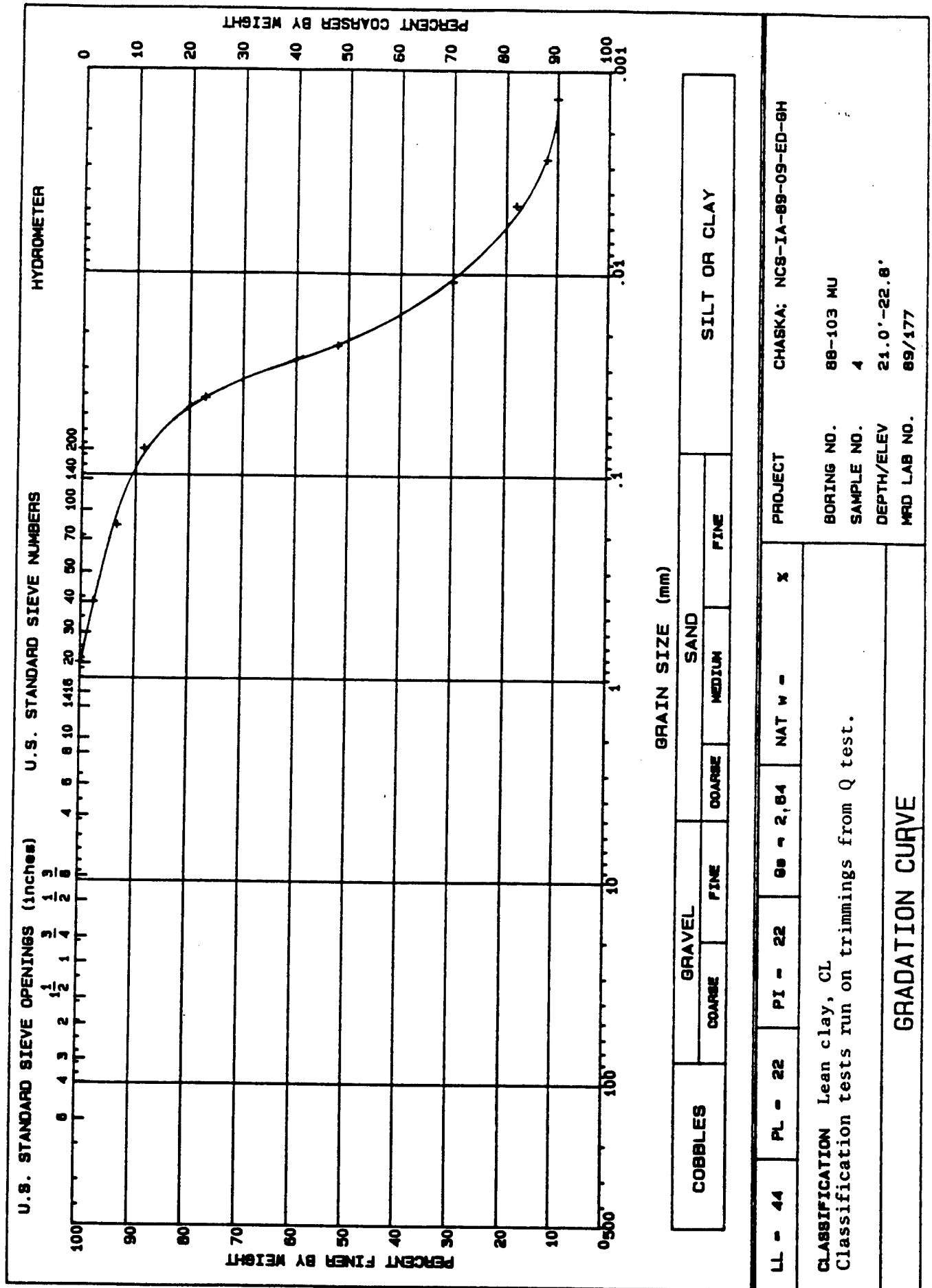
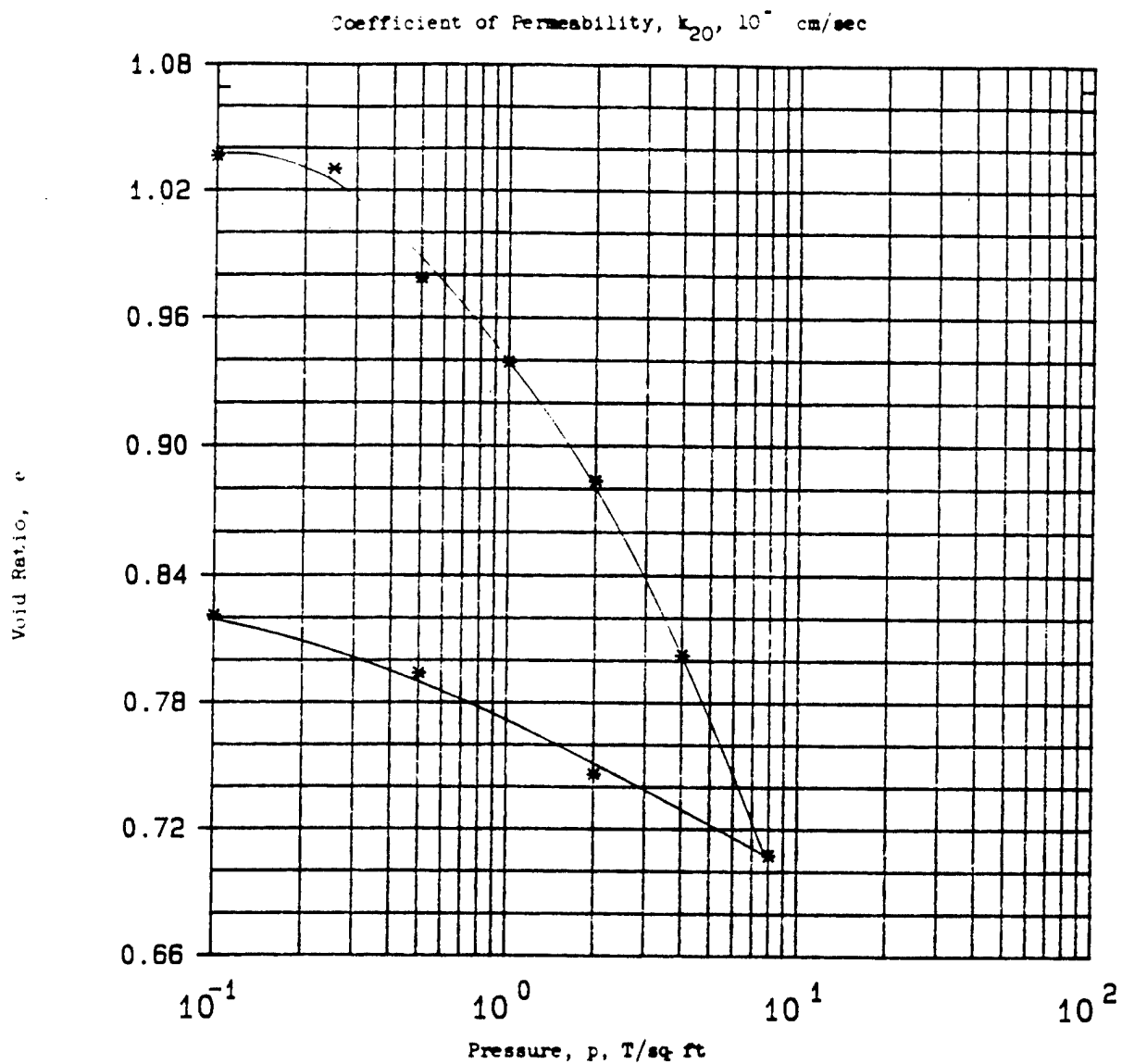
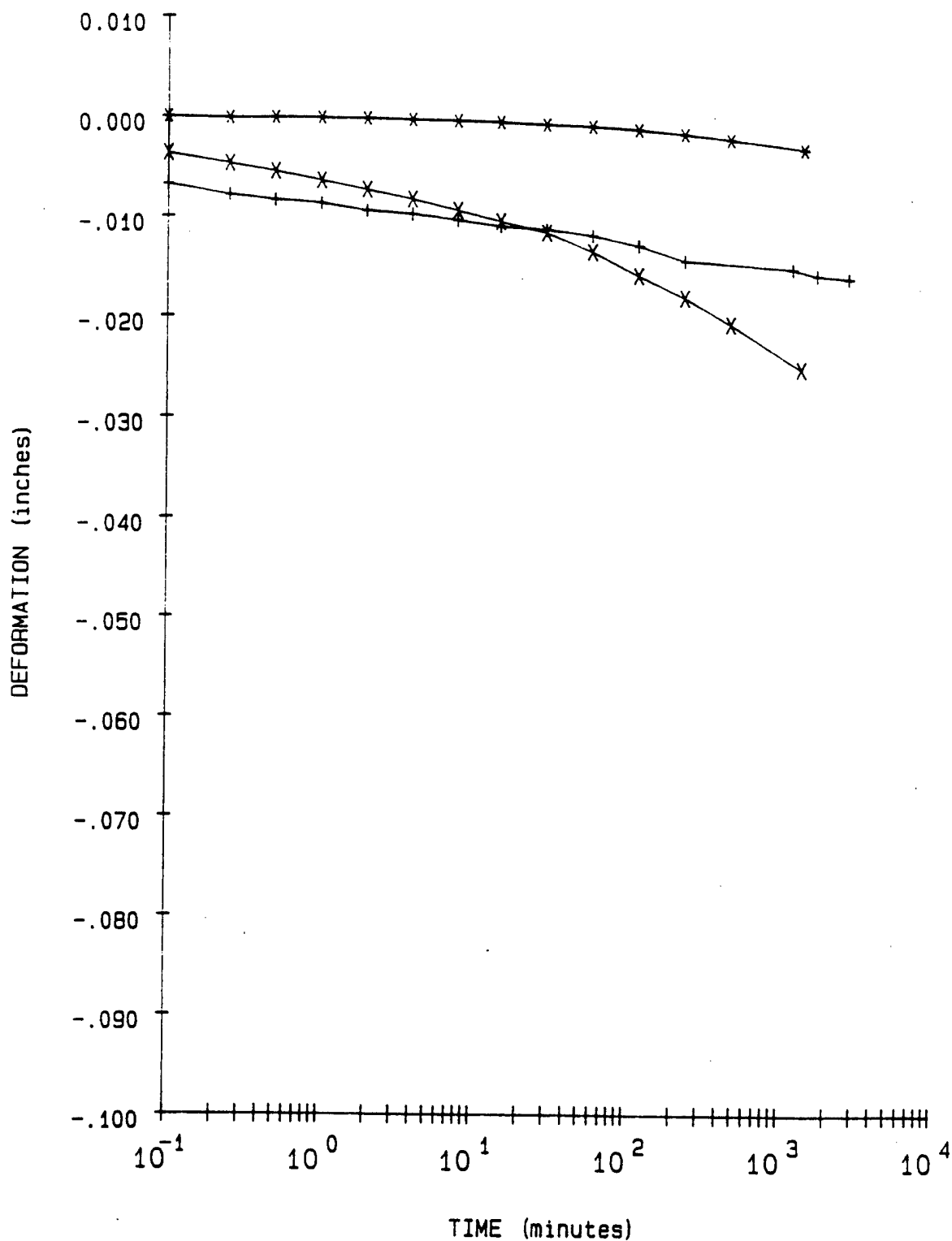


Figure C-275



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	1 in.	Water Content, $w_o$	36.0 %	$w_f$	37.9 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	1.07	$e_f$	0.82
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	86 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	76.6 lb/ft <sup>3</sup>		
Classification		Fat clay, CH		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL	84	$G_s$	2.54	Project			
PL	32	$D_{10}$		MINNESOTA RIVER: IA-90-04-ED-GH			
Remarks Dark gray, no Torvane. Slightly calcareous.				Area			
				MRD LAB NO. 90/135			
				Boring No. 89-7 MU		Sample No. S-1	
				Depth			
				El 3'-4.1'		Date	
<b>CONSOLIDATION TEST REPORT</b>							





LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-7 MU

SAMPLE NO.

S-1

DEPTH/ELEV

3'-4.1'

MRO LAB NO.

90/135

FIGURE 2

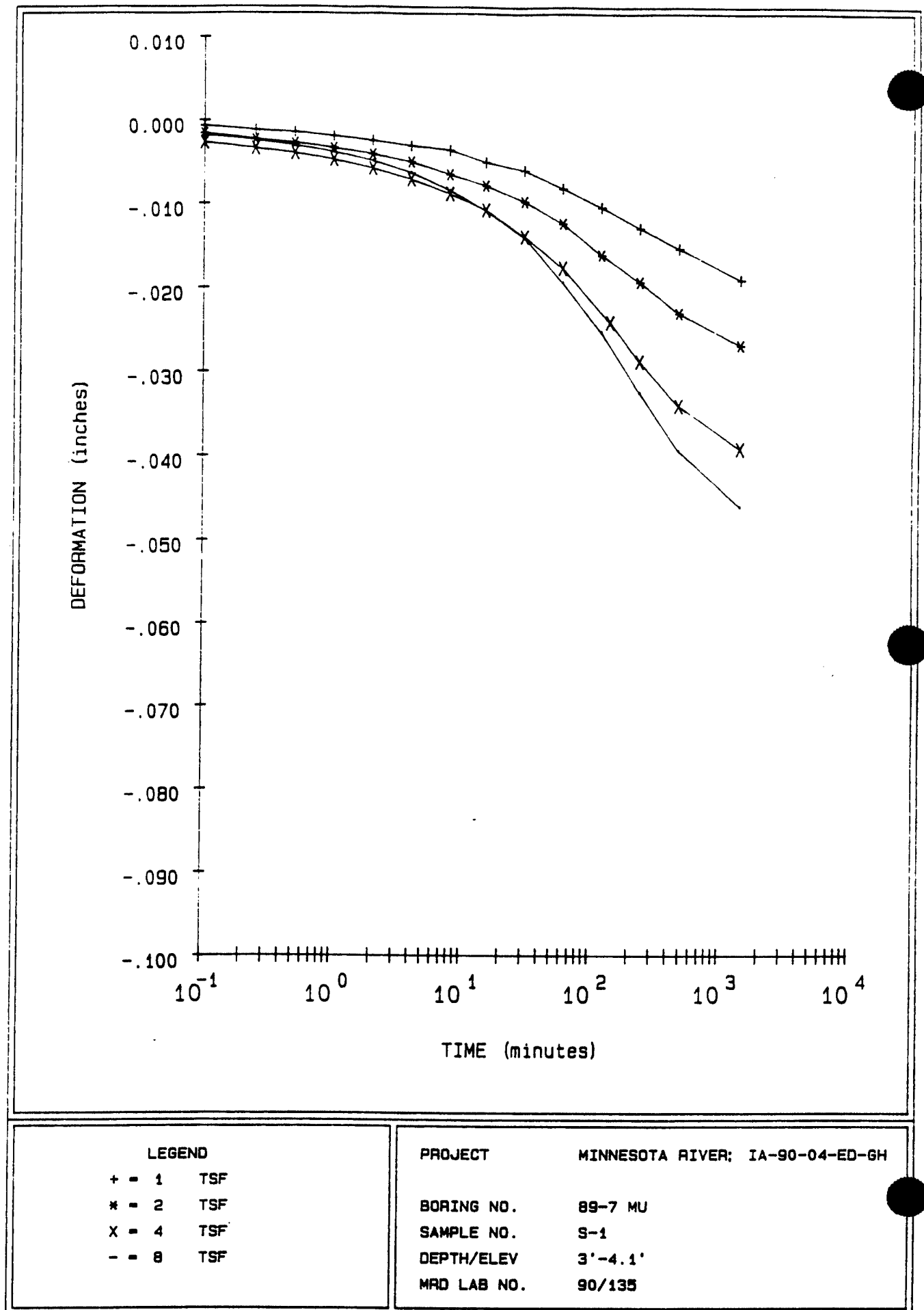
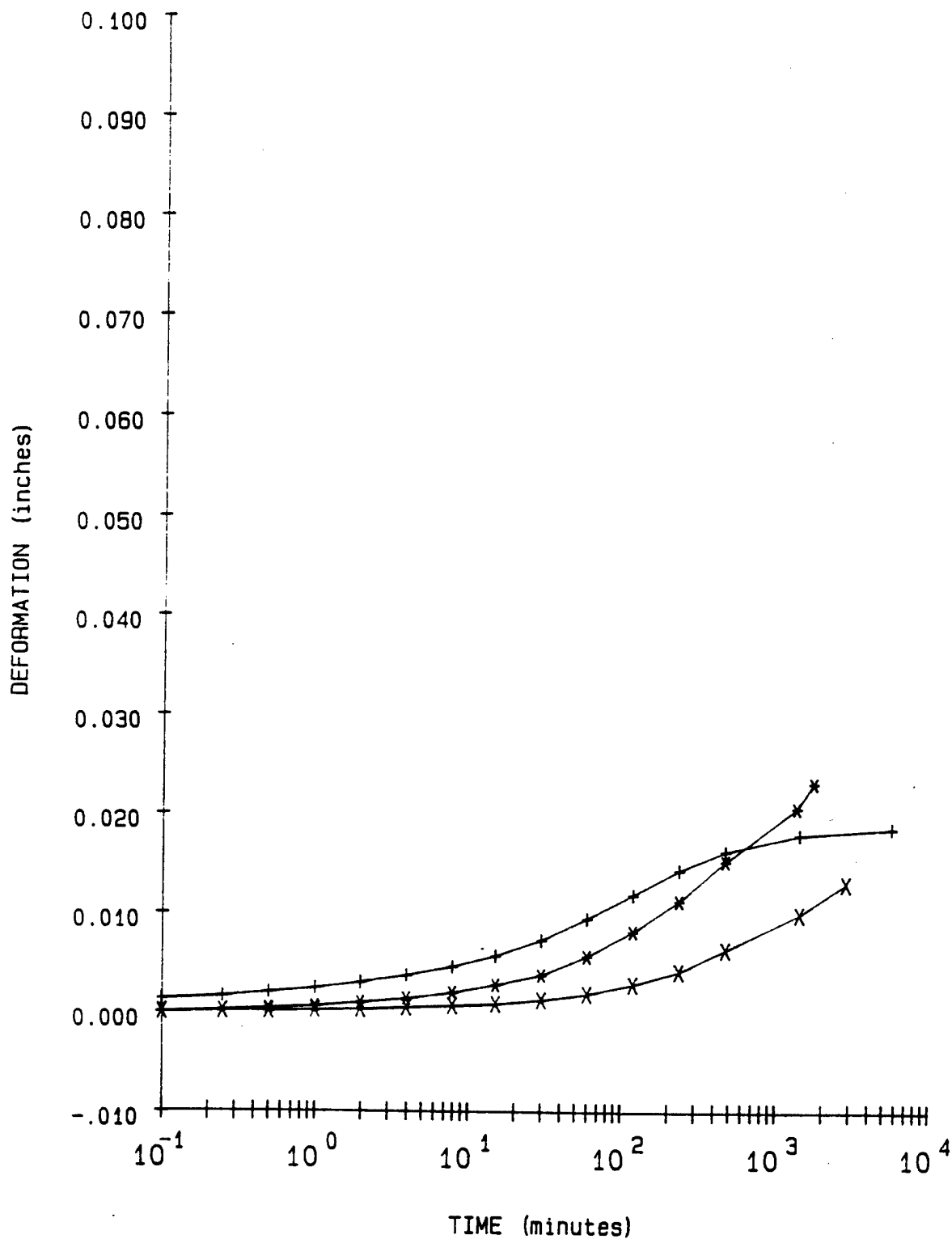


FIGURE 3  
Figure C-278



LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-7 MU

SAMPLE NO.

S-1

DEPTH/ELEV

3'-4.1'

MRD LAB NO.

90/135

FIGURE 4

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-7 MU

Sample No. S-1

Depth/Elev 3'-4.1'

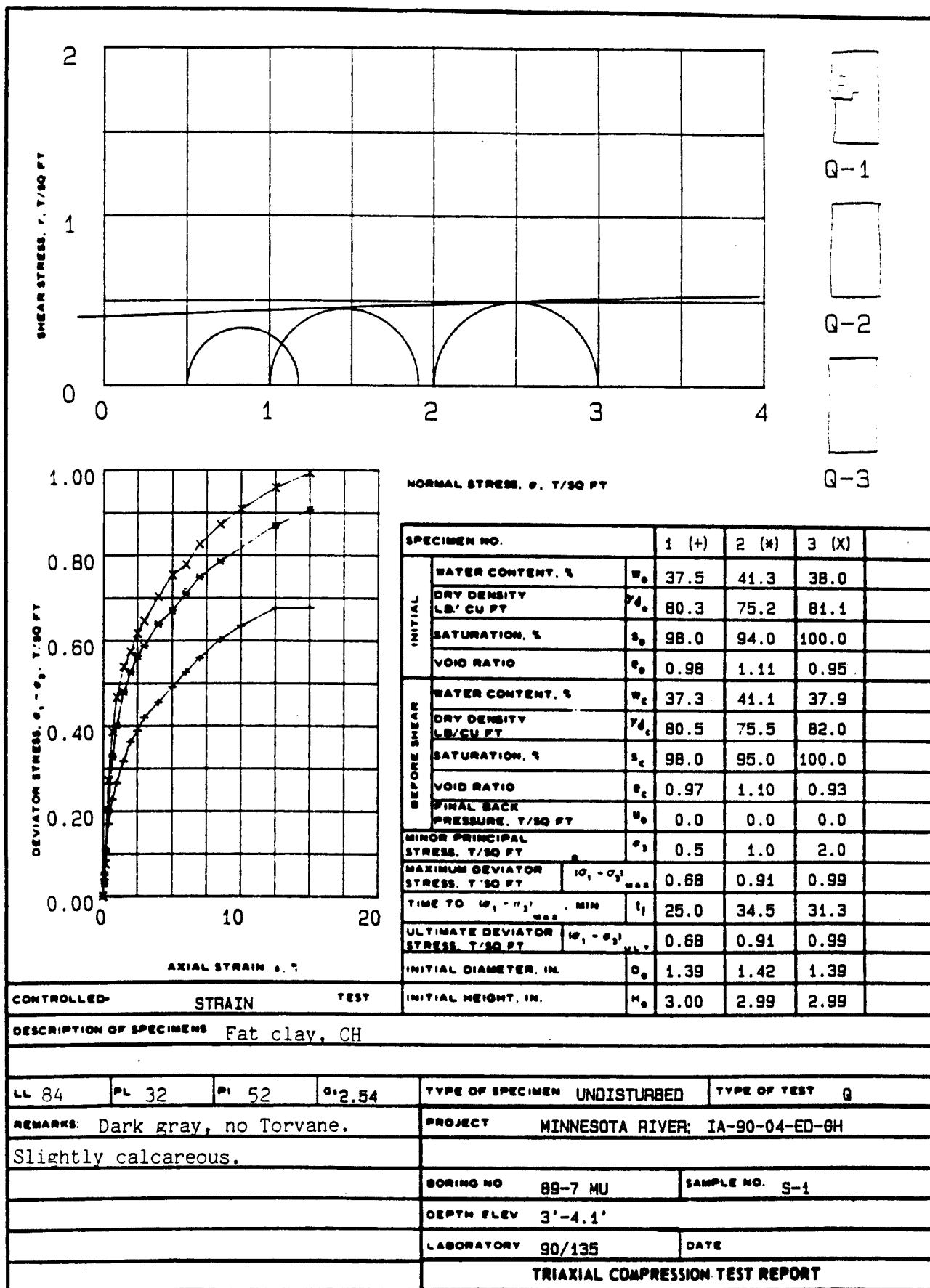
MRD Lab No. 90/135

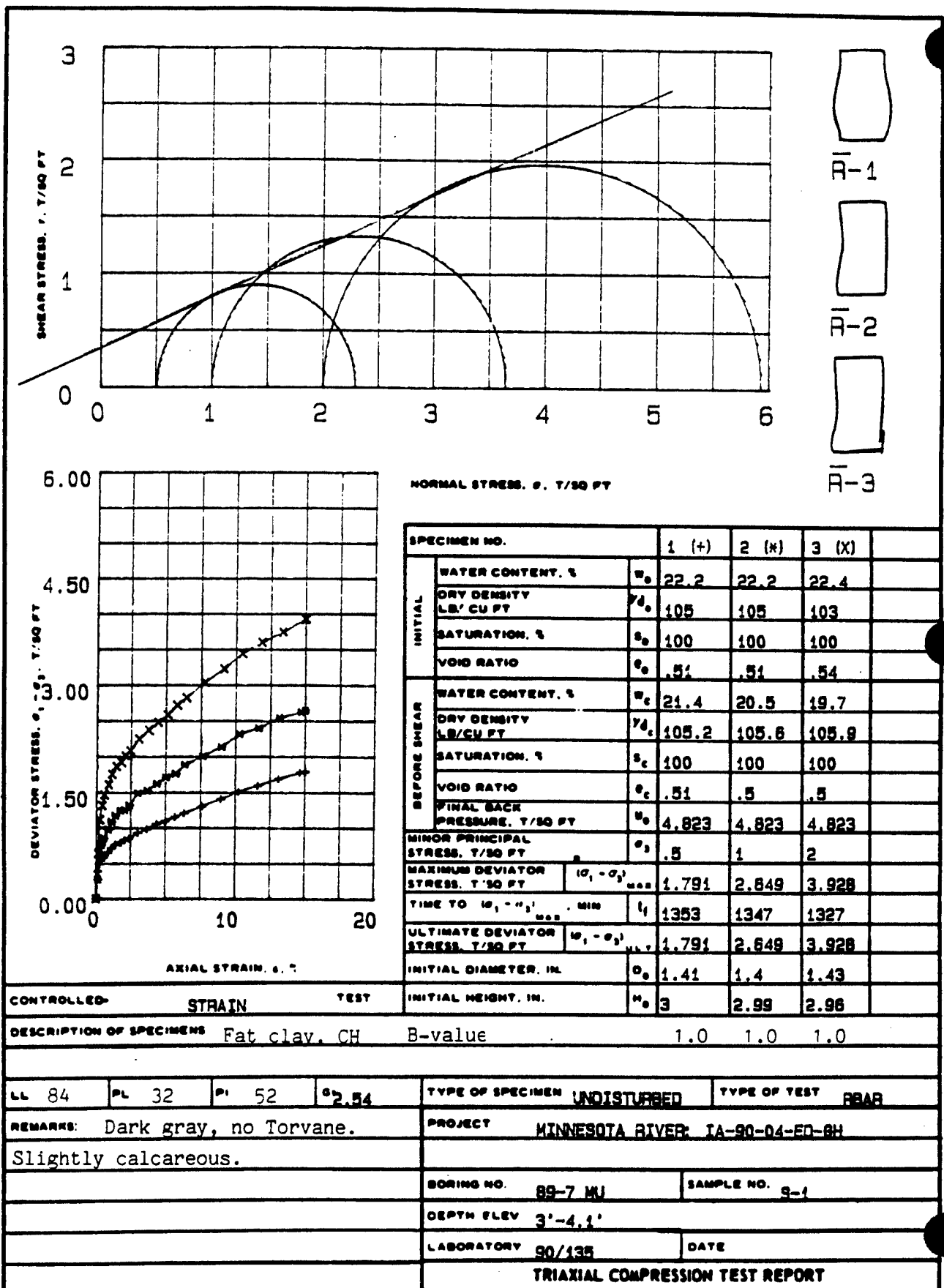
Gs = 2.54  
eo = 1.069  
0.42eo = 0.449

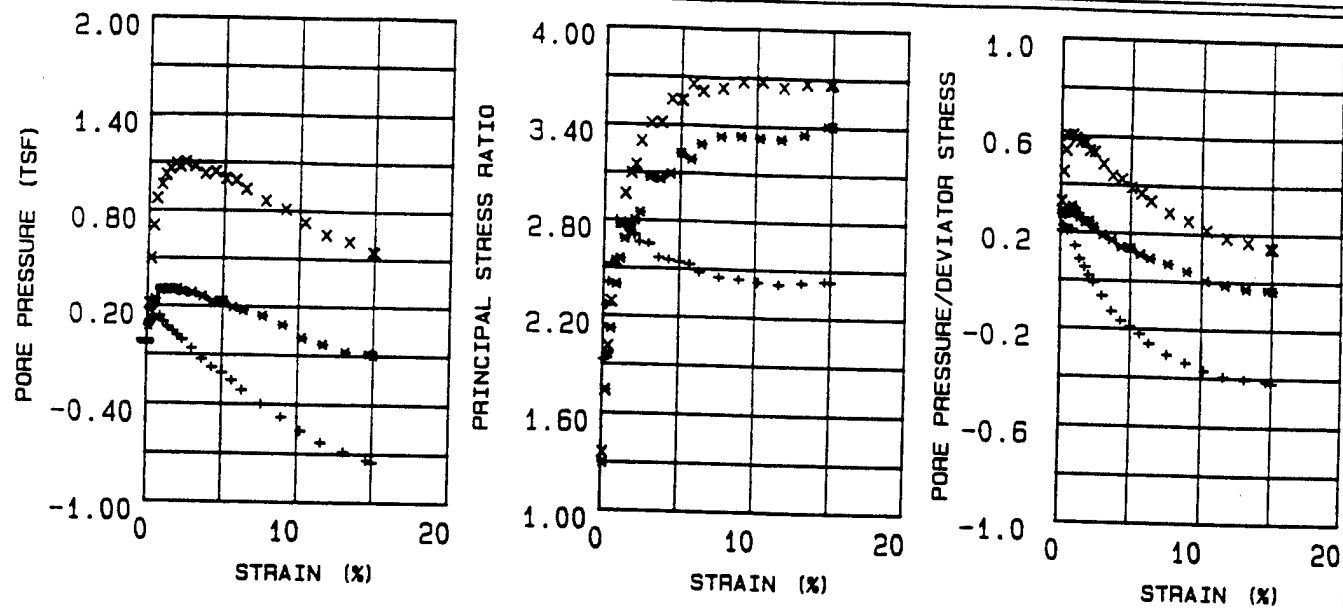
Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
36.0	290.1	76.6	1.069		85.6
37.9	290.1	77.8	1.036	0.10	92.8
37.9	290.1	78.1	1.030	0.25	93.4
37.9	290.1	80.1	0.978	0.50	98.3
37.9	290.1	81.7	0.939	1.00	100.0
37.9	290.1	84.1	0.884	2.00	100.0
37.9	290.1	87.9	0.802	4.00	100.0
37.9	290.1	92.8	0.707	8.00	100.0
37.9	290.1	90.8	0.746	2.00	100.0
37.9	290.1	88.3	0.794	0.50	100.0
37.9	290.1	87.0	0.821	0.10	100.0

Axial Strain (%)      Void Ratio

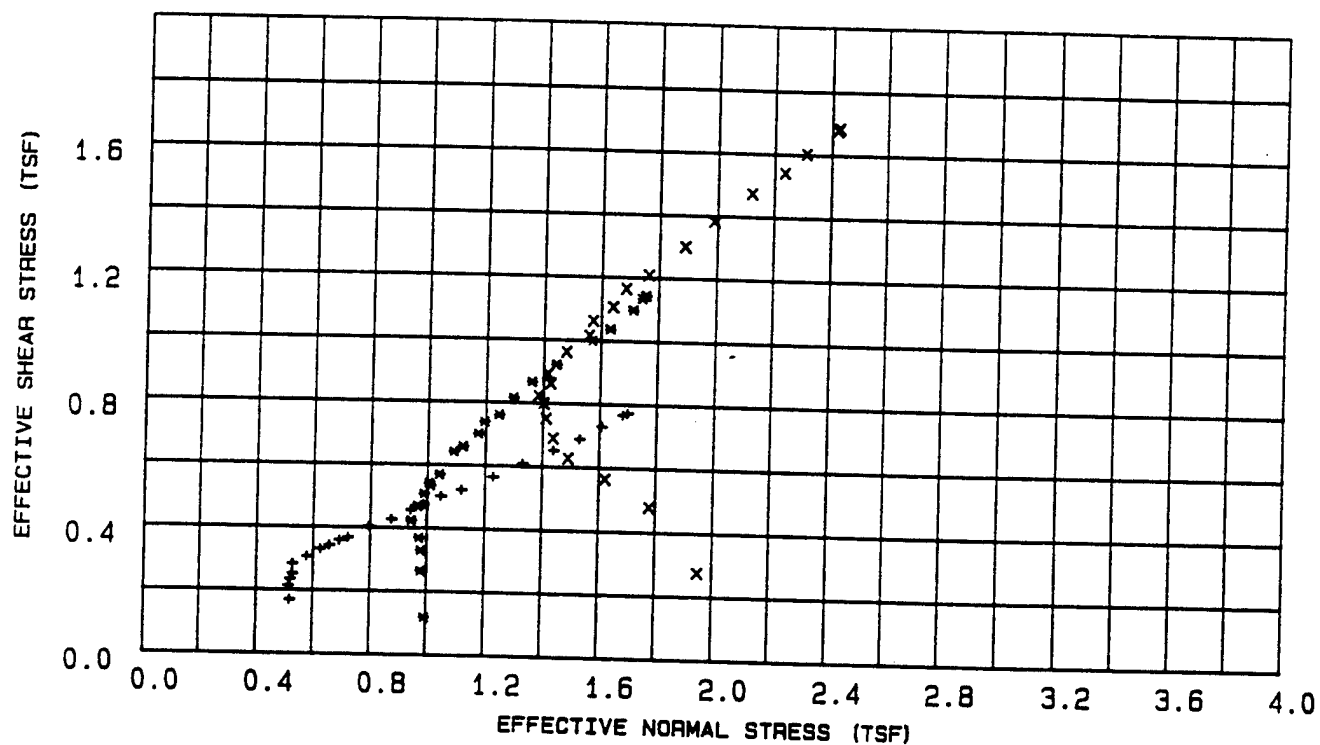
1	1.048
2	1.028
3	1.007
4	0.986
5	0.966
6	0.945
7	0.924
8	0.903
9	0.883
10	0.862
11	0.841
12	0.821
13	0.800
14	0.779
15	0.759
16	0.738
17	0.717
18	0.697
19	0.676
20	0.655







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-7 MU

SAMPLE NO.

S-1

DEPTH/ELEV

3'-4.1'

MRO LAB NO.

90/135

FIGURE 7

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-1  
 Depth : 3'-4.1'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.390	0.079	1.925	0.203	0.518	0.168
30	0.24	0.492	0.110	2.260	0.224	0.512	0.212
45	0.38	0.541	0.115	2.406	0.213	0.519	0.234
60	0.55	0.582	0.117	2.521	0.202	0.527	0.251
90	0.85	0.654	0.136	2.798	0.209	0.526	0.282
120	1.09	0.710	0.099	2.770	0.140	0.577	0.306
150	1.38	0.765	0.065	2.759	0.085	0.624	0.330
180	1.76	0.793	0.040	2.723	0.051	0.656	0.342
210	2.04	0.830	0.014	2.707	0.017	0.691	0.358
240	2.37	0.849	-0.011	2.661	-0.013	0.721	0.367
300	2.99	0.930	-0.064	2.650	-0.068	0.794	0.402
360	3.65	0.984	-0.130	2.563	-0.132	0.874	0.425
420	4.32	1.054	-0.180	2.550	-0.170	0.941	0.45
480	4.98	1.098	-0.214	2.538	-0.194	0.986	0.474
540	5.65	1.157	-0.259	2.525	-0.223	1.046	0.500
600	6.31	1.208	-0.319	2.475	-0.263	1.118	0.521
720	7.59	1.307	-0.404	2.446	-0.308	1.228	0.564
840	8.92	1.409	-0.481	2.436	-0.341	1.330	0.608
960	10.20	1.509	-0.564	2.419	-0.373	1.438	0.651
1080	11.58	1.595	-0.634	2.407	-0.397	1.529	0.688
1200	13.08	1.688	-0.689	2.420	-0.407	1.607	0.729
1320	14.62	1.776	-0.741	2.431	-0.417	1.681	0.767
1353	15.00	1.791	-0.754	2.428	-0.421	1.697	0.773



Table 2 - Triaxial  $\bar{R}$  Test Results

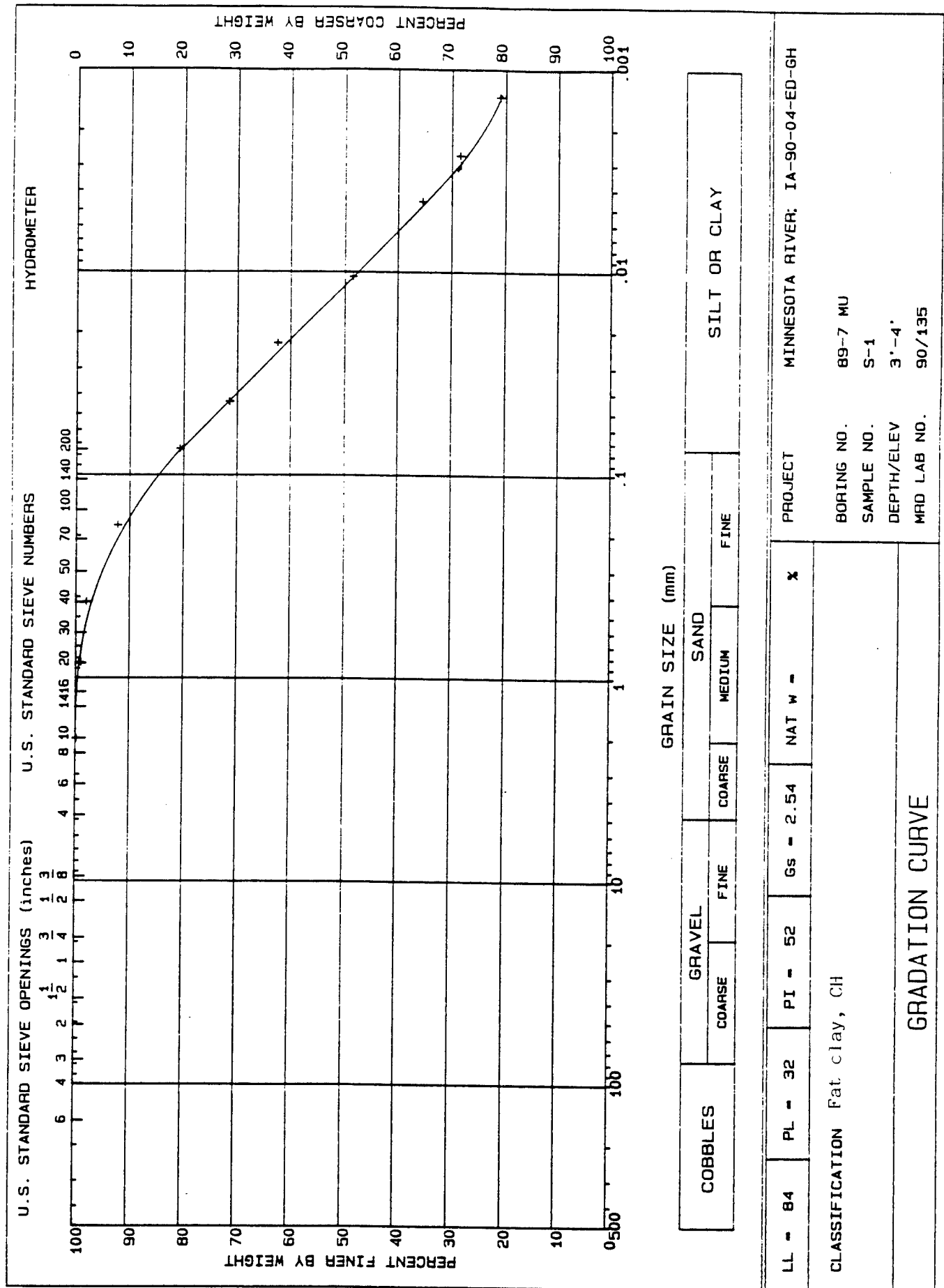
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-1  
 Depth : 3'-4.1'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.272	0.074	1.293	0.272	0.993	0.117
30	0.24	0.611	0.173	1.739	0.284	0.978	0.264
45	0.38	0.760	0.210	1.963	0.277	0.978	0.328
60	0.55	0.852	0.240	2.120	0.282	0.971	0.368
90	0.86	0.978	0.299	2.396	0.307	0.943	0.422
120	1.10	1.086	0.303	2.558	0.279	0.966	0.469
150	1.38	1.174	0.303	2.684	0.258	0.988	0.507
180	1.76	1.241	0.297	2.765	0.240	1.010	0.535
210	2.05	1.253	0.305	2.803	0.244	1.005	0.541
240	2.38	1.320	0.286	2.849	0.218	1.041	0.570
300	3.00	1.490	0.279	3.067	0.188	1.090	0.643
360	3.67	1.528	0.257	3.057	0.169	1.121	0.659
420	4.34	1.620	0.226	3.092	0.140	1.175	0.699
480	5.01	1.711	0.229	3.219	0.134	1.195	0.738
500	5.68	1.764	0.192	3.182	0.109	1.245	0.761
600	6.34	1.887	0.172	3.279	0.092	1.295	0.815
720	7.63	2.007	0.139	3.331	0.070	1.358	0.866
840	8.96	2.138	0.085	3.337	0.040	1.444	0.923
960	10.25	2.317	0.004	3.325	0.002	1.570	1.000
1080	11.64	2.402	-0.036	3.318	-0.015	1.631	1.037
1200	13.14	2.544	-0.081	3.354	-0.031	1.711	1.098
1320	14.69	2.629	-0.092	3.407	-0.035	1.743	1.135
1347	15.00	2.649	-0.101	3.406	-0.038	1.756	1.143

Table 3 - Triaxial  $\bar{R}$  Test Results

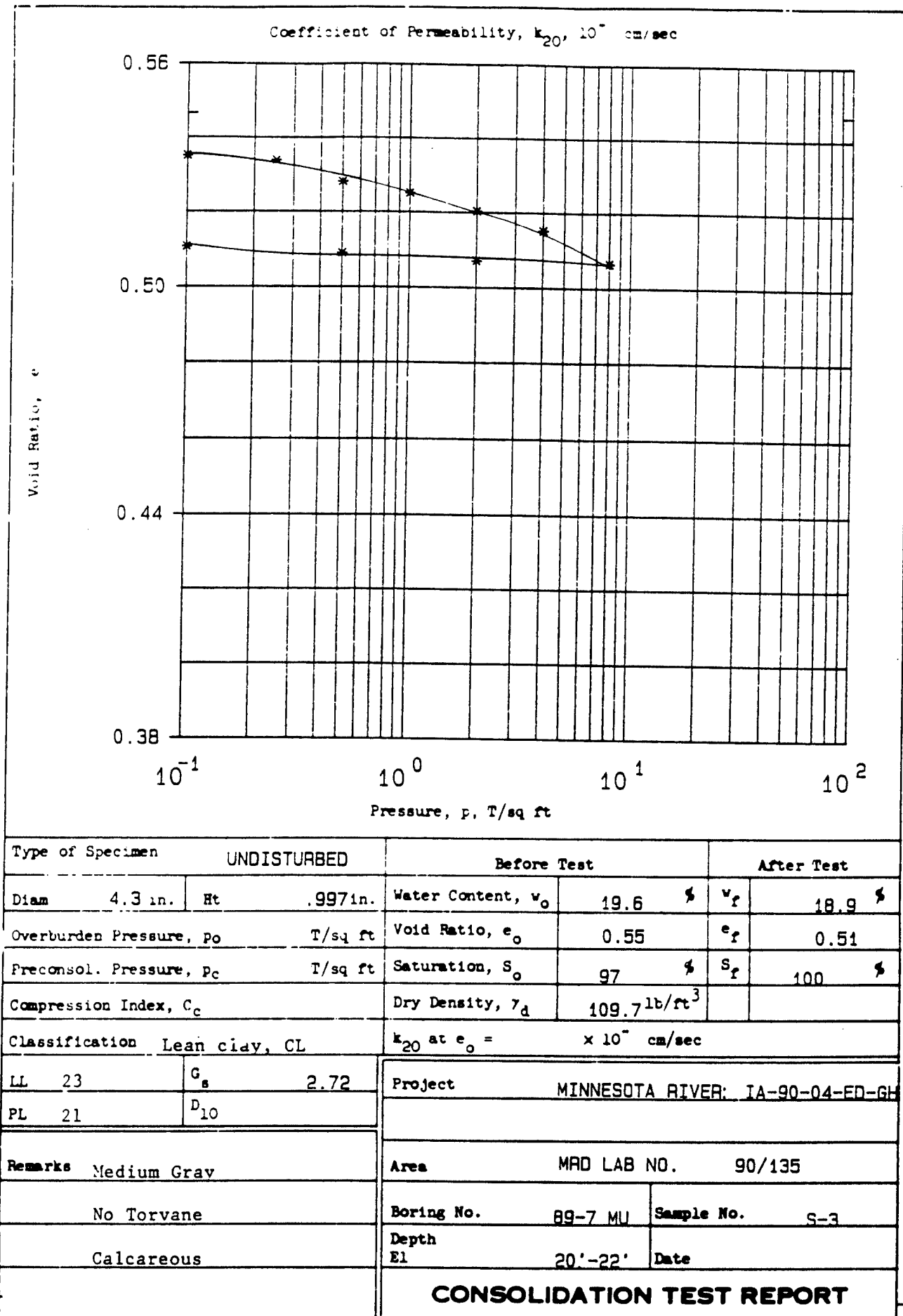
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-1  
 Depth : 3'-4.1'  
 Confining Pressure : 2 TSF

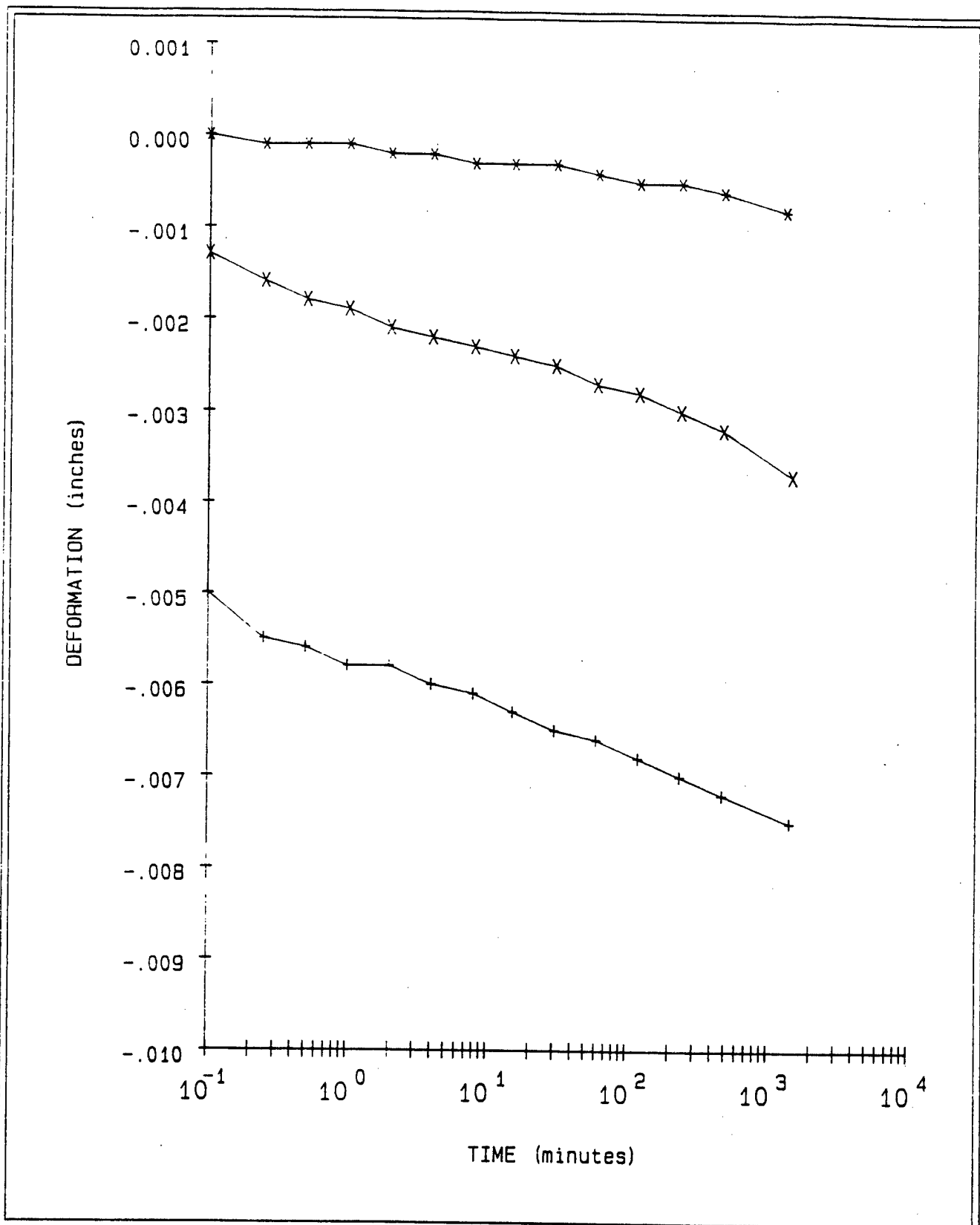
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.638	0.208	1.356	0.326	1.950	0.275
30	0.24	1.107	0.496	1.736	0.449	1.778	0.478
45	0.39	1.306	0.702	2.007	0.538	1.621	0.564
60	0.56	1.453	0.871	2.287	0.600	1.489	0.627
90	0.87	1.596	0.960	2.535	0.602	1.435	0.689
120	1.11	1.740	1.022	2.779	0.588	1.409	0.751
150	1.40	1.849	1.058	2.963	0.573	1.400	0.798
180	1.78	1.905	1.091	3.094	0.573	1.381	0.822
210	2.07	1.995	1.070	3.145	0.537	1.424	0.861
240	2.41	2.068	1.099	3.295	0.532	1.413	0.892
300	3.04	2.228	1.075	3.409	0.483	1.477	0.962
360	3.71	2.353	1.025	3.414	0.436	1.557	1.015
420	4.38	2.459	1.039	3.559	0.423	1.570	1.061
480	5.06	2.563	0.996	3.553	0.389	1.639	1.10
540	5.74	2.697	0.984	3.655	0.365	1.684	1.164
600	6.41	2.798	0.929	3.613	0.333	1.764	1.208
720	7.71	3.011	0.857	3.634	0.285	1.889	1.300
840	9.06	3.200	0.804	3.675	0.252	1.988	1.381
960	10.36	3.413	0.725	3.676	0.213	2.120	1.473
1080	11.76	3.569	0.649	3.642	0.182	2.235	1.541
1200	13.28	3.712	0.608	3.667	0.164	2.311	1.602
1320	14.84	3.888	0.543	3.668	0.140	2.420	1.678
1333	15.00	3.902	0.540	3.672	0.139	2.426	1.684



LL - 84					PL - 32	PI - 52	Gs - 2.54	NAT W -	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
CLASSIFICATION Fat clay, CH										BORING NO.	89-7 MU
										SAMPLE NO.	S-1
										DEPTH/ELEV	3'-4'
										MRD LAB NO.	90/135
GRADATION CURVE											

FIGURE 8

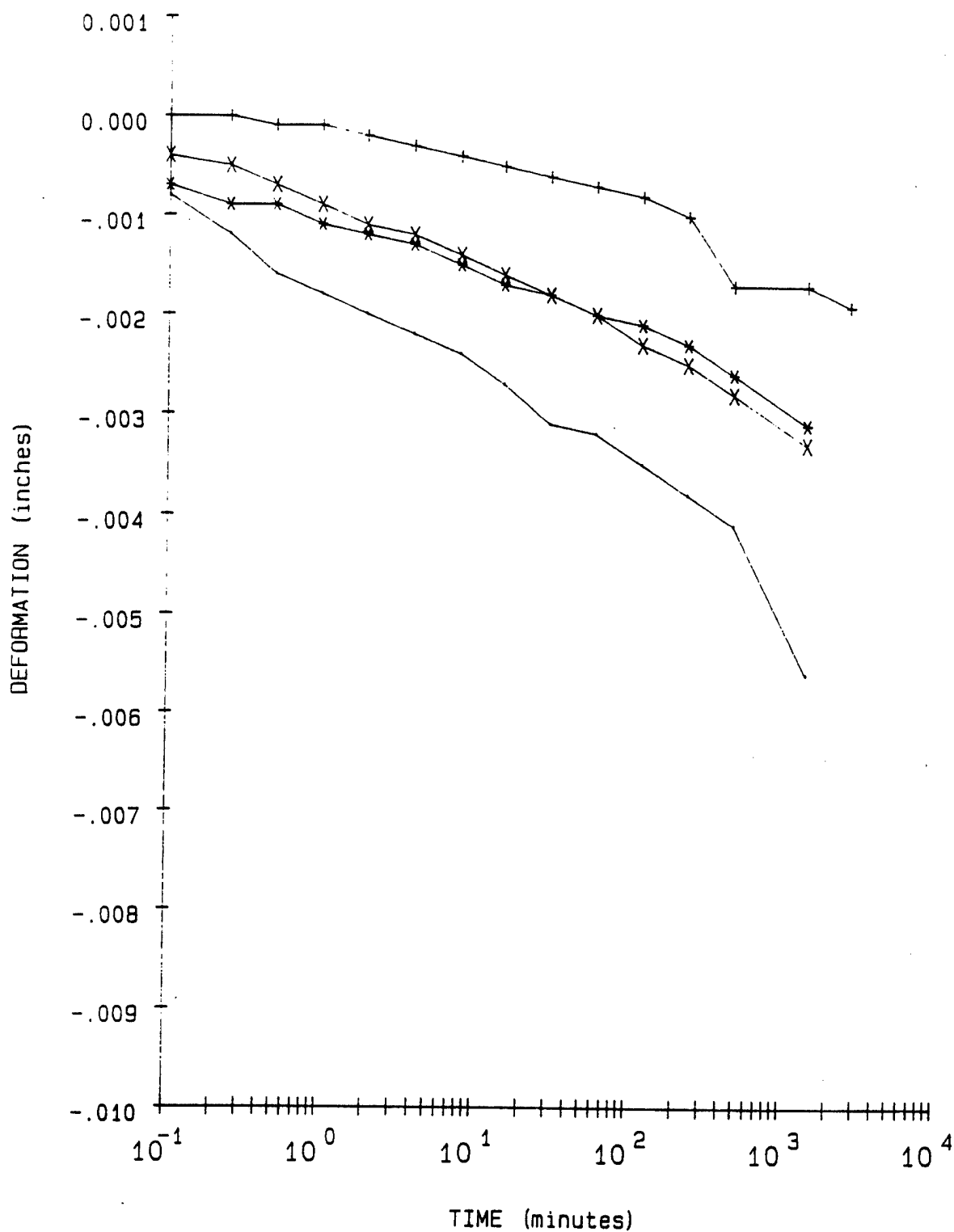




LEGEND  
 + = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT MINNESOTA RIVER; IA-90-04-ED-GH  
 BORING NO. 89-7 MU  
 SAMPLE NO. S-3  
 DEPTH/ELEV 20'-22'  
 MRD LAB NO. 90/135

FIGURE 2



#### LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 X = 4 TSF  
 - = 8 TSF

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

#### BORING NO.

89-7 MU

#### SAMPLE NO.

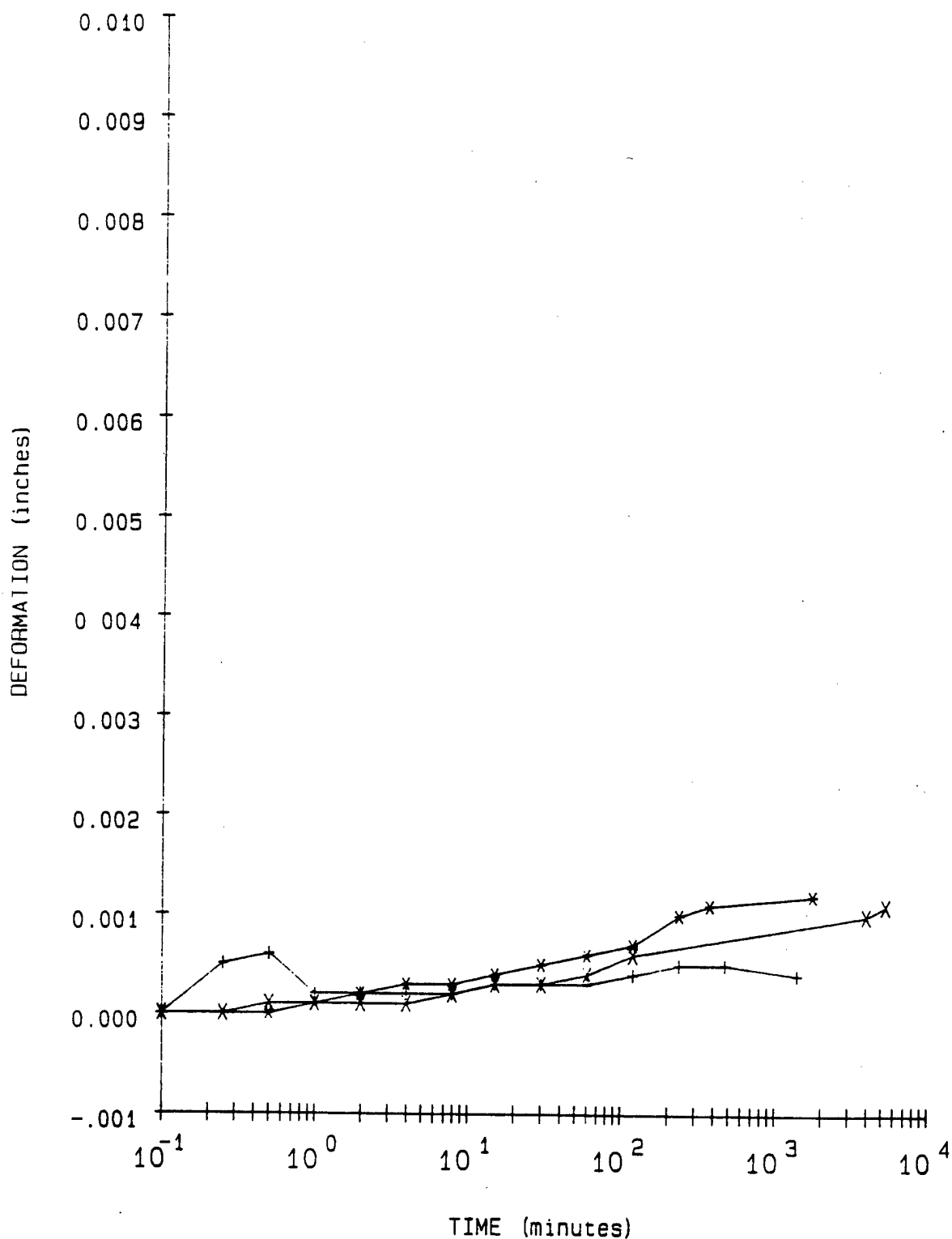
S-3

#### DEPTH/ELEV

20'-22'

#### MAD LAB NO.

90/135



#### LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-6H

BORING NO. 89-7 MU

SAMPLE NO. S-3

DEPTH/ELEV 20'-22'

MRD LAB NO. 90/135

FIGURE 4

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-7 MU

Sample No. S-3

Depth/Elev 20'-22'

MRD Lab No. 90/135

Gs = 2.72

eo = 0.547

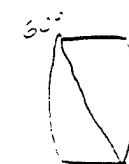
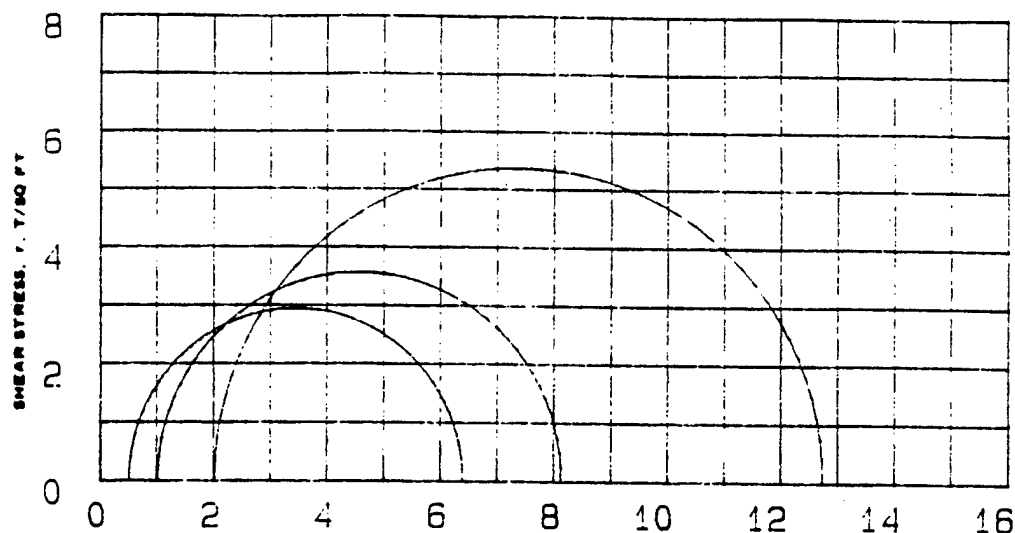
0.42eo = 0.230

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
19.6	415.7	109.7	0.547		97.4
18.9	415.7	110.6	0.535	0.10	96.3
18.9	415.7	110.7	0.534	0.25	96.5
18.9	415.7	111.1	0.528	0.50	97.6
18.9	415.7	111.3	0.525	1.00	98.1
18.9	415.7	111.6	0.520	2.00	99.0
18.9	415.7	112.0	0.515	4.00	100.0
18.9	415.7	112.7	0.506	8.00	100.0
18.9	415.7	112.6	0.507	2.00	100.0
18.9	415.7	112.5	0.509	0.50	100.0
18.9	415.7	112.4	0.511	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.531
2	0.516
3	0.500
4	0.485
5	0.469

Consolidation Test Data





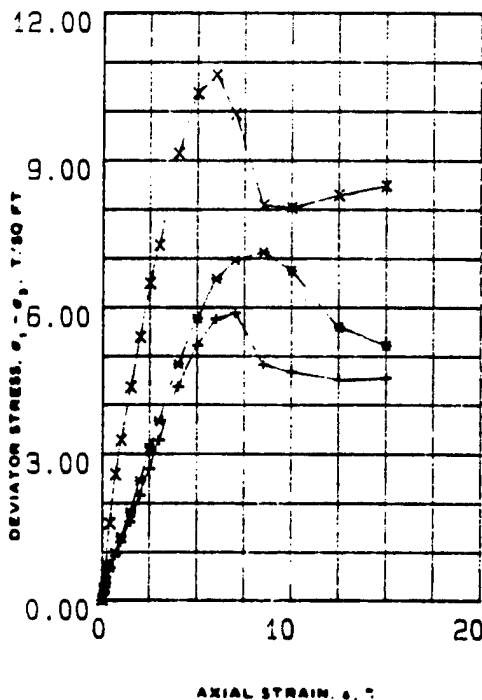
Q-1



Q-2



Q-3



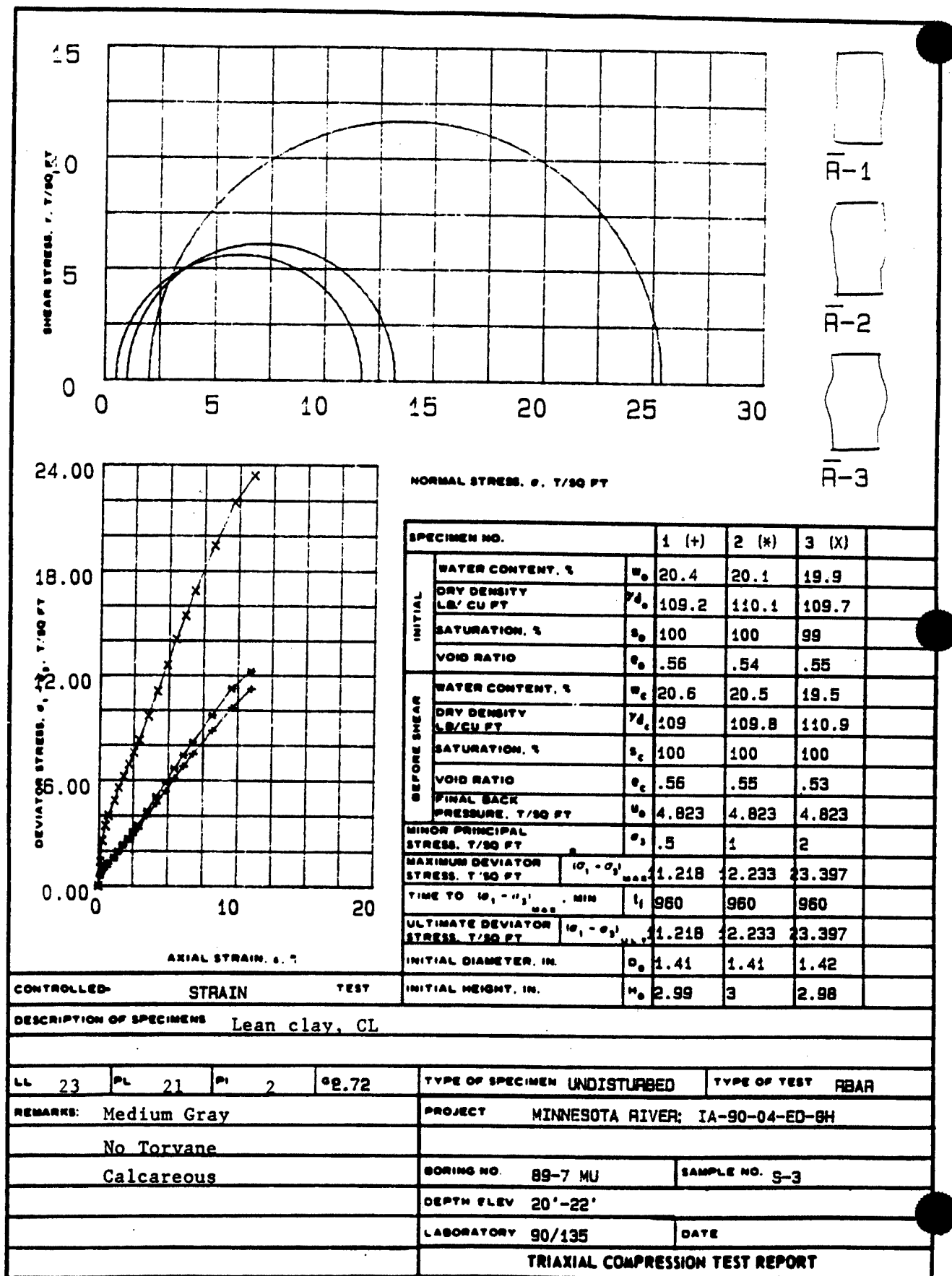
NORMAL STRESS,  $\sigma$ , T/50 FT

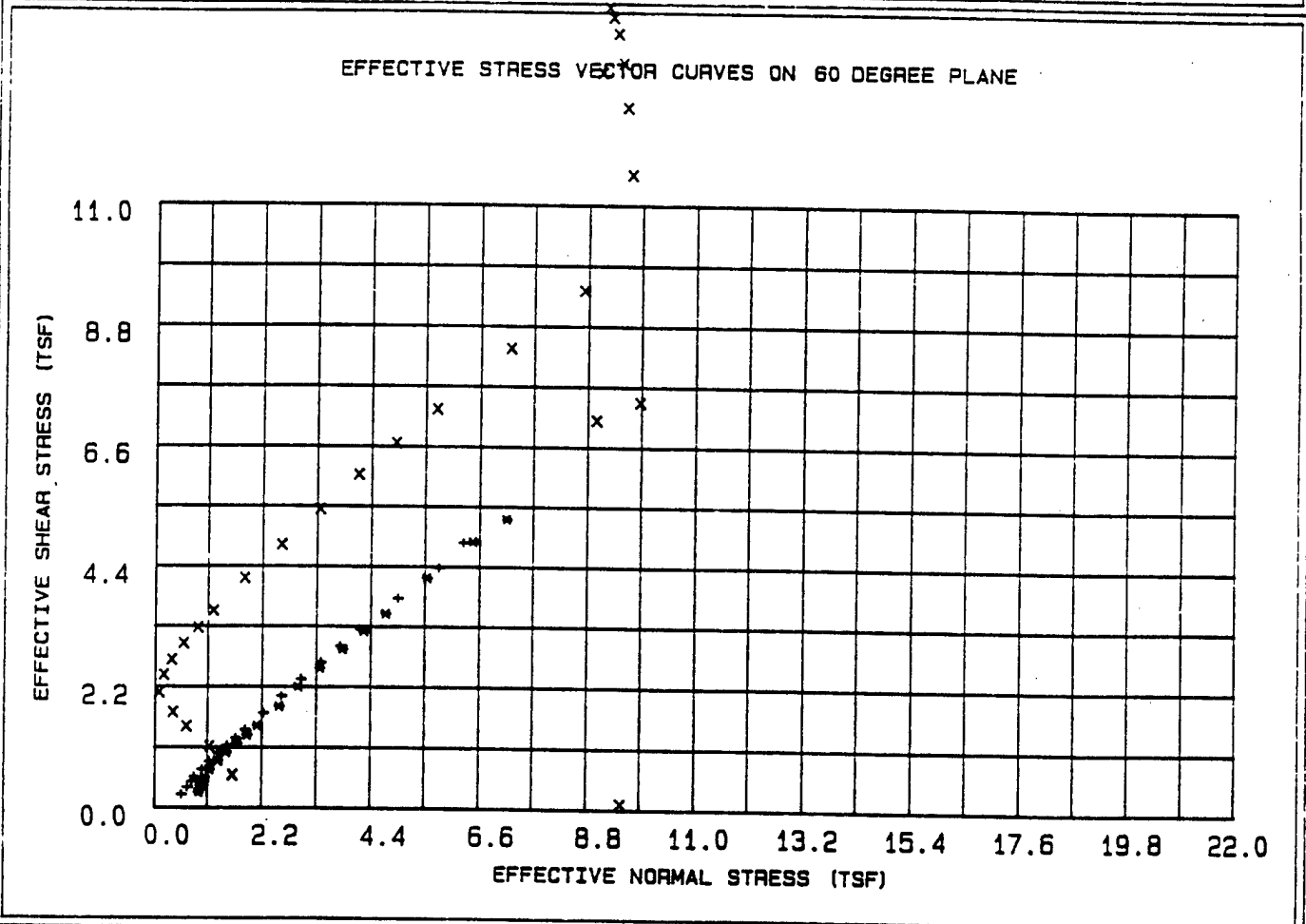
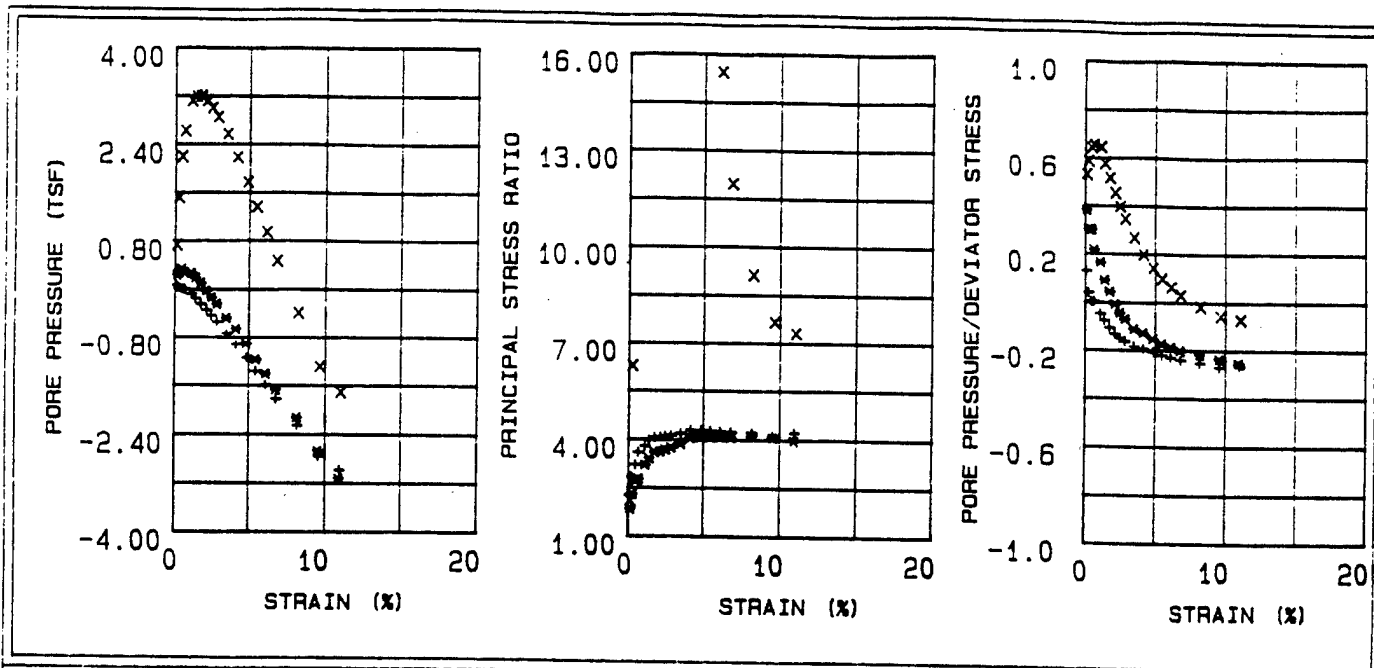
SPECIMEN NO.		1 (+)	2 (*)	3 (X)
INITIAL	WATER CONTENT, %	W <sub>o</sub> 18.4	18.4	18.2
	DRY DENSITY LB/CU FT	$\gamma_d$ 113.2	113.0	112.3
	SATURATION, %	S <sub>o</sub> 100.0	99.0	97.0
	VOID RATIO	e <sub>o</sub> 0.50	0.50	0.51
BEFORE SHEAR	WATER CONTENT, %	W <sub>c</sub> 18.3	18.4	18.1
	DRY DENSITY LB/CU FT	$\gamma_d$ 113.2	113.0	112.3
	SATURATION, %	S <sub>c</sub> 100.0	99.0	96.0
	VOID RATIO	e <sub>c</sub> 0.50	0.50	0.51
FINAL BACK PRESSURE, T/50 FT		U <sub>o</sub> 0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		$\sigma_3$ 0.5	1.0	2.0
MAXIMUM DEVIATOR STRESS, T/50 FT		( $\sigma_1 - \sigma_3$ ) <sub>max</sub> 5.89	7.13	10.74
TIME TO ( $\sigma_1 - \sigma_3$ ) <sub>max</sub> , MIN		t <sub>f</sub> 17.0	22.3	18.5
ULTIMATE DEVIATOR STRESS, T/50 FT		( $\sigma_1 - \sigma_3$ ) <sub>ult</sub> 4.55	5.22	8.48
INITIAL DIAMETER, IN.		D <sub>o</sub> 1.42	1.42	1.40
INITIAL HEIGHT, IN.		H <sub>o</sub> 3.00	3.00	3.00

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS Lean clay, CL

LL 23	PL 21	PI 2	$q_u$ 2.72	TYPE OF SPECIMEN UNDISTURBED	TYPE OF TEST q
REMARKS: Medium Gray				PROJECT MINNESOTA RIVER; IA-90-04-ED-6H	
No Torvane					
Calcareous					
				BORING NO. 89-7MU	SAMPLE NO. S-3
				DEPTH FLEV 20'-22'	
				LABORATORY 90/135	DATE
TRIAXIAL COMPRESSION TEST REPORT					





LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-7 MU

SAMPLE NO.

S-3

DEPTH/ELEV

20'-22'

MRD LAB NO.

90/135

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-3  
 Depth : 20'-22'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.542	0.069	2.259	0.128	0.565	0.234
30	0.26	0.851	0.032	2.817	0.038	0.679	0.367
45	0.48	1.105	0.000	3.211	0.001	0.774	0.477
60	0.67	1.291	0.001	3.589	0.002	0.819	0.557
90	1.12	1.615	-0.081	3.780	-0.050	0.981	0.697
120	1.40	1.940	-0.152	3.978	-0.078	1.132	0.837
150	1.76	2.279	-0.247	4.051	-0.108	1.311	0.983
180	2.14	2.614	-0.352	4.067	-0.134	1.499	1.128
210	2.47	2.931	-0.446	4.098	-0.152	1.672	1.265
240	2.85	3.278	-0.547	4.130	-0.166	1.859	1.415
300	3.49	3.977	-0.745	4.195	-0.187	2.230	1.717
360	4.14	4.692	-0.925	4.291	-0.197	2.587	2.025
420	4.83	5.401	-1.145	4.284	-0.211	2.982	2.331
480	5.44	6.114	-1.374	4.262	-0.224	3.388	2.639
540	6.08	6.798	-1.597	4.242	-0.234	3.780	2.934
600	6.77	7.500	-1.828	4.222	-0.243	4.185	3.237
720	8.15	8.831	-2.259	4.200	-0.255	4.945	3.812
840	9.55	10.140	-2.766	4.104	-0.272	5.776	4.376
960	10.96	11.218	-2.991	4.213	-0.266	6.268	4.842

Table 2 - Triaxial  $\bar{R}$  Test Results

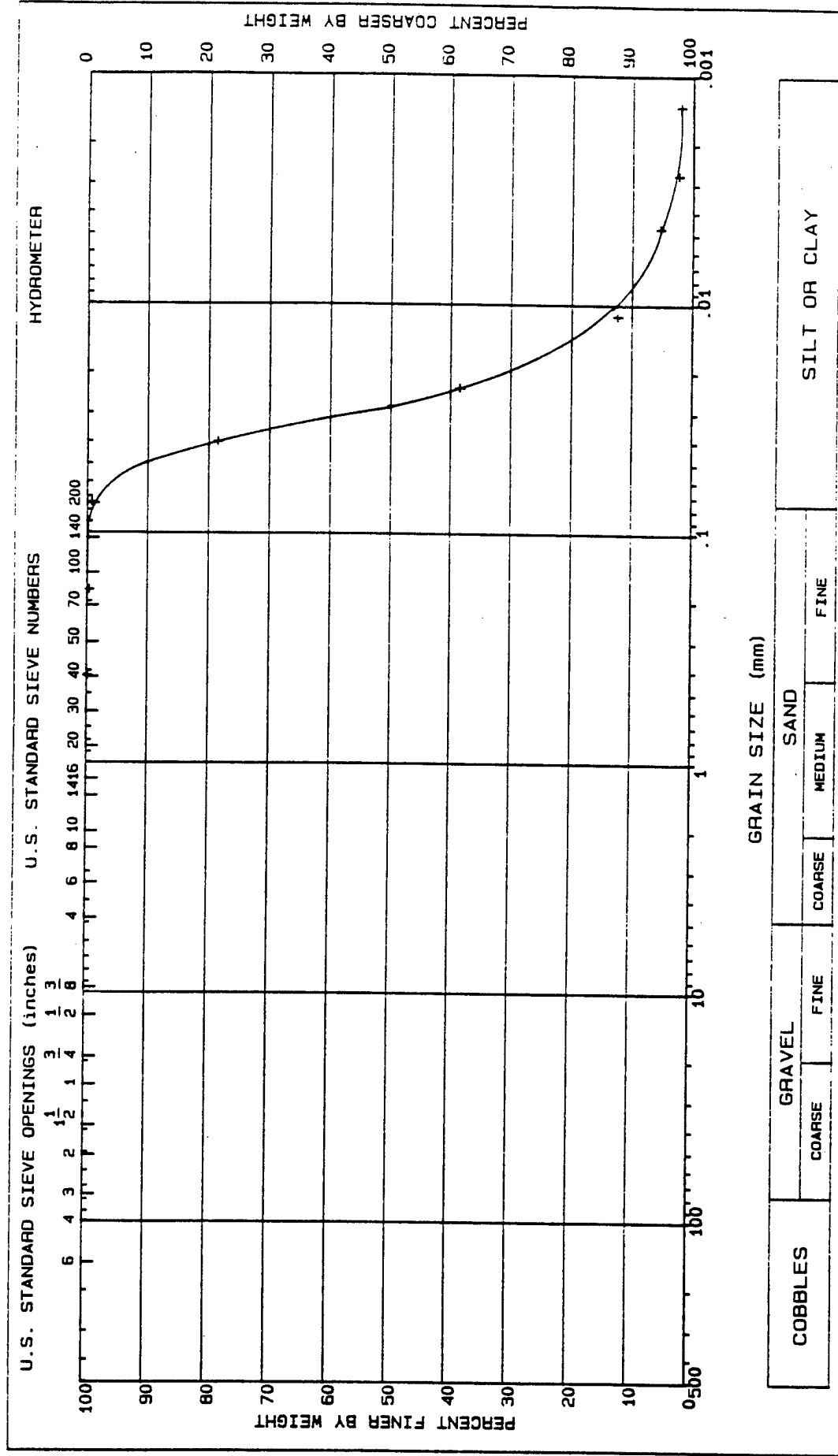
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-3  
 Depth : 20'-22'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.632	0.239	1.830	0.380	0.917	0.273
30	0.26	0.929	0.278	2.287	0.300	0.952	0.401
45	0.47	1.130	0.337	2.704	0.299	0.943	0.488
60	0.66	1.275	0.274	2.757	0.215	1.042	0.550
90	1.11	1.618	0.263	3.196	0.163	1.138	0.698
120	1.40	1.981	0.178	3.410	0.090	1.312	0.855
150	1.76	2.339	0.100	3.600	0.043	1.479	1.010
180	2.13	2.694	-0.029	3.617	-0.010	1.696	1.163
210	2.47	3.066	-0.142	3.685	-0.046	1.901	1.323
240	2.84	3.451	-0.249	3.763	-0.072	2.104	1.490
300	3.48	4.256	-0.484	3.867	-0.113	2.538	1.837
360	4.12	5.085	-0.663	4.059	-0.130	2.922	2.195
420	4.81	5.864	-0.912	4.067	-0.155	3.364	2.531
480	5.43	6.672	-1.176	4.066	-0.176	3.828	2.880
540	6.07	7.431	-1.418	4.073	-0.190	4.258	3.207
600	6.75	8.175	-1.674	4.057	-0.204	4.698	3.528
720	8.13	9.714	-2.132	4.101	-0.219	5.537	4.192
840	9.53	11.250	-2.678	4.059	-0.238	6.463	4.856
960	10.92	12.233	-3.126	3.965	-0.255	7.155	5.280

Table 3 - Triaxial  $\bar{R}$  Test Results

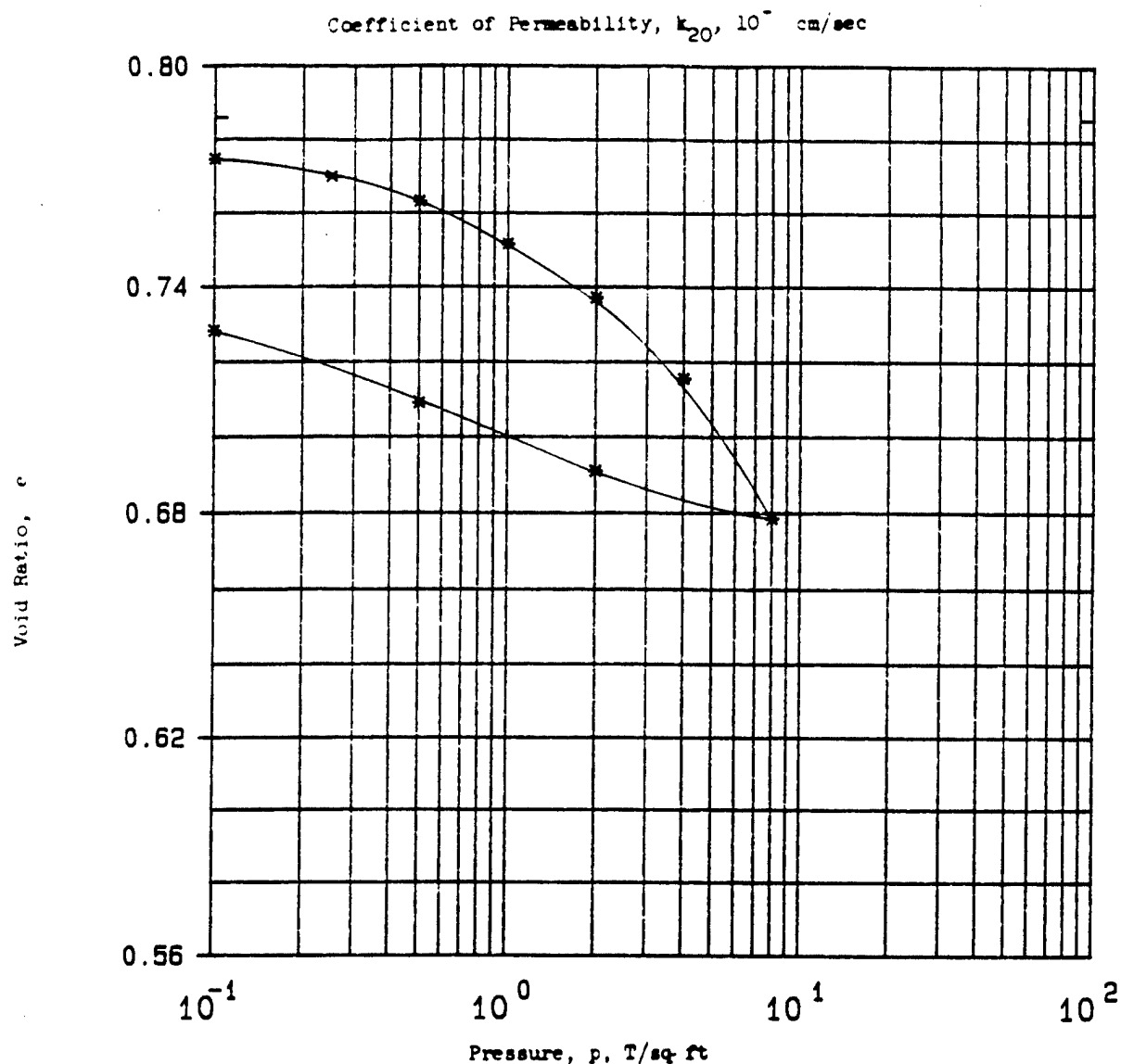
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-3  
 Depth : 20'-22'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	1.379	0.731	2.086	0.530	1.610	0.595
30	0.26	2.579	1.511	6.269	0.586	1.127	1.113
45	0.48	3.421	2.192	%-16.842	0.641	0.655	1.477
60	0.67	4.012	2.619	-5.484	0.653	0.374	1.732
90	1.13	4.851	3.116	-3.345	0.643	0.085	2.094
120	1.41	5.577	3.196	-3.664	0.574	0.185	2.407
150	1.77	6.212	3.192	-4.210	0.514	0.346	2.681
180	2.15	6.905	3.116	-5.185	0.452	0.594	2.980
210	2.49	7.581	2.993	-6.635	0.395	0.884	3.272
240	2.87	8.280	2.843	-8.823	0.344	1.207	3.574
300	3.52	9.674	2.561	%-16.256	0.265	1.834	4.175
360	4.17	11.096	2.176	%-62.086	0.197	2.571	4.1
420	4.86	12.603	1.765	54.561	0.141	3.355	5.439
480	5.48	14.082	1.352	22.724	0.096	4.134	6.078
540	6.13	15.427	0.932	15.441	0.061	4.887	6.658
600	6.82	16.867	0.459	11.944	0.028	5.717	7.280
720	8.21	19.447	-0.399	9.107	-0.020	7.214	8.393
840	9.63	21.890	-1.294	7.646	-0.059	8.713	9.448
960	11.04	23.397	-1.717	7.294	-0.073	9.510	10.098



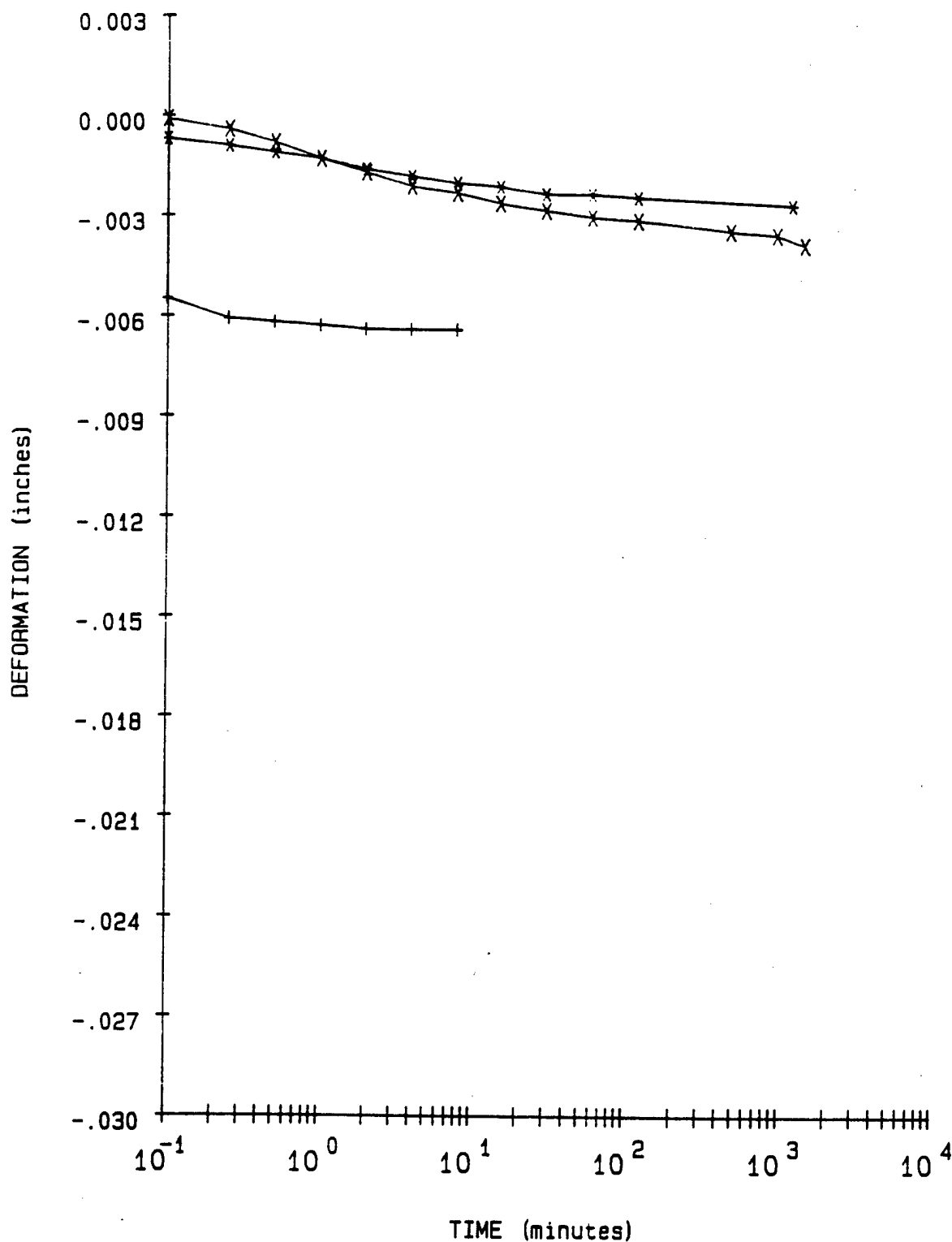
LL - 23	PL - 21	PI - 2	Gs - 2.72	NAT w -	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
CLASSIFICATION						BORING NO.	89-7 MU
Lean clay, CL						SAMPLE NO.	S-3
GRADATION CURVE						DEPTH/ELEV	20'-22'
						MRD LAB NO.	90/_35

FIGURE 8



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.4 in.	Ht	1 in.	Water Content, $w_o$	29.3 %	$w_f$	27.9 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	0.79	$e_f$	0.73
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	100 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	94.3 lb/ft <sup>3</sup>		
Classification		Lean clay, CL		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL 47	$G_s$	2.7		Project			
PL 19	$D_{10}$			MINNESOTA RIVER; IA-90-04-ED-6H			
Remarks		Gray		Area			
		Torvane=0.65 TSF		MRD LAB NO. 90/135			
		Calcareous		Boring No. 89-7 MU		Sample No. S-5	
				Depth El 30'-32'		Date	
				<b>CONSOLIDATION TEST REPORT</b>			





**LEGEND**

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

**PROJECT**

MINNESOTA RIVER: IA-90-04-ED-GH

**BORING NO.**

89-7 MU

**SAMPLE NO.**

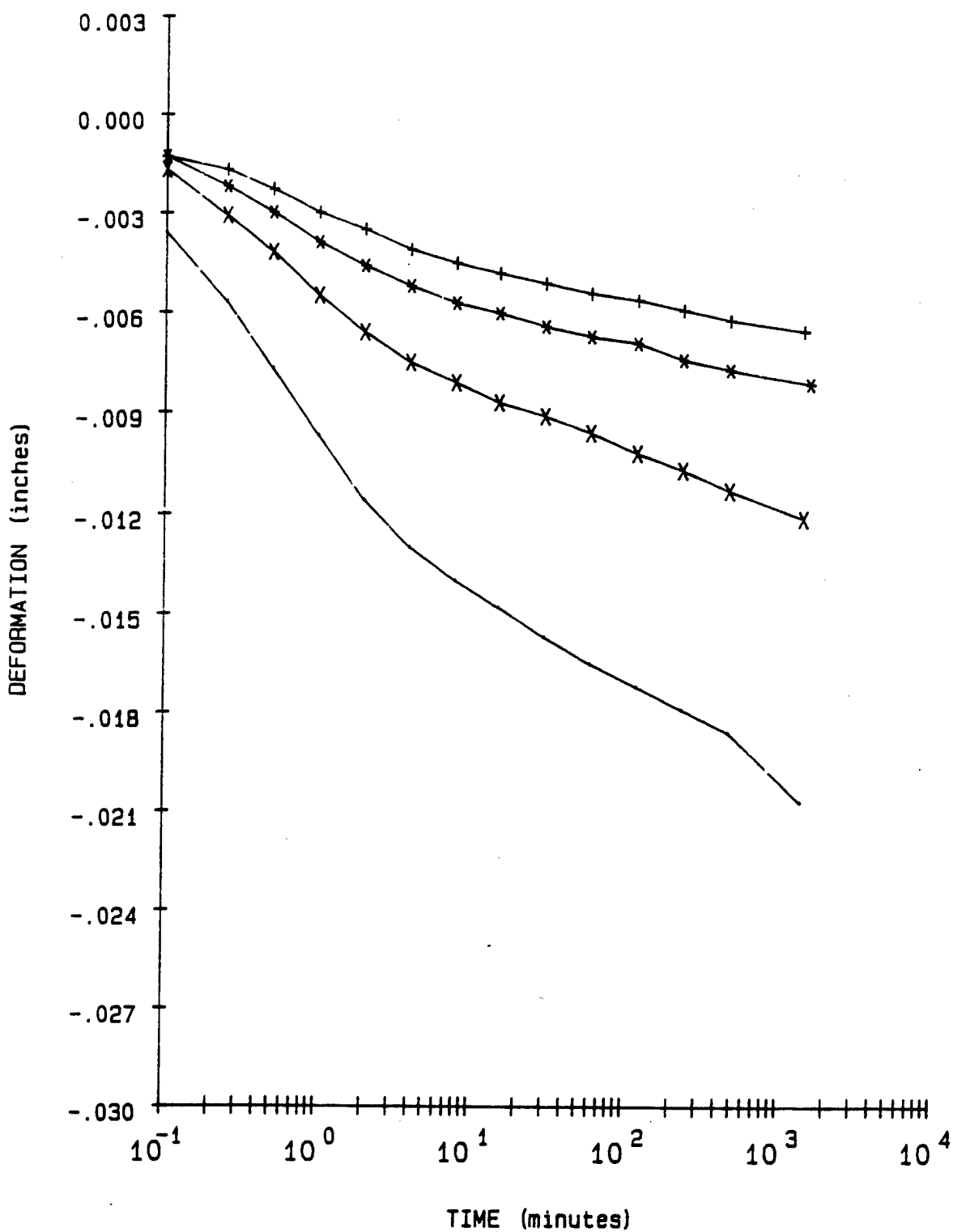
S-5

**DEPTH/ELEV**

30'-32'

**MRO LAB NO.**

90/135



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-7 MU

SAMPLE NO.

S-5

DEPTH/ELEV

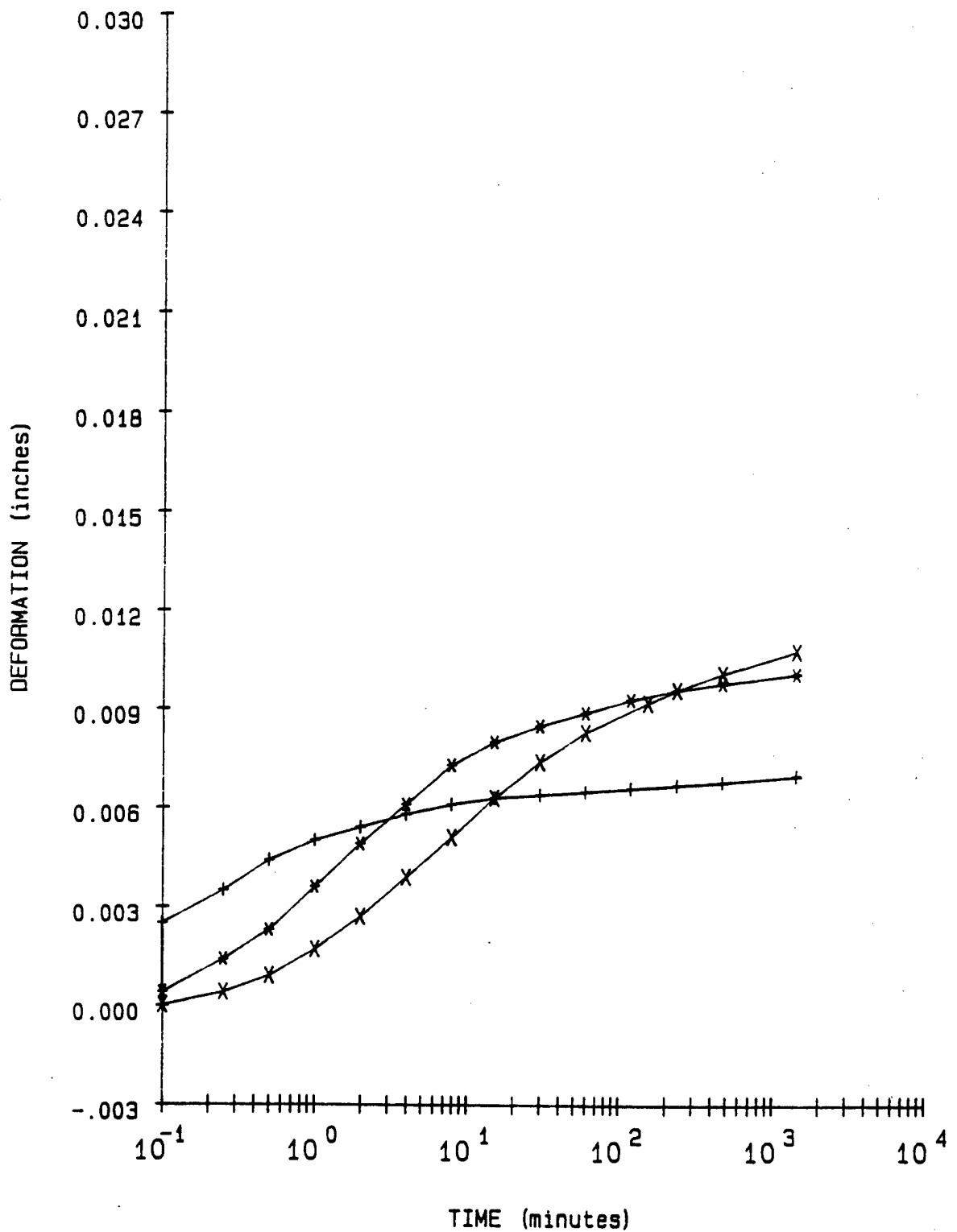
30'-32'

MRD LAB NO.

90/135

FIGURE 11

Figure C-302



#### LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

#### PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO. 89-7 MU

SAMPLE NO. S-5

DEPTH/ELEV 30'-32'

MRD LAB NO. 90/135

FIGURE 12

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-7 MU

Sample No. S-5

Depth/Elev 30'-32'

MRD Lab No. 90/135

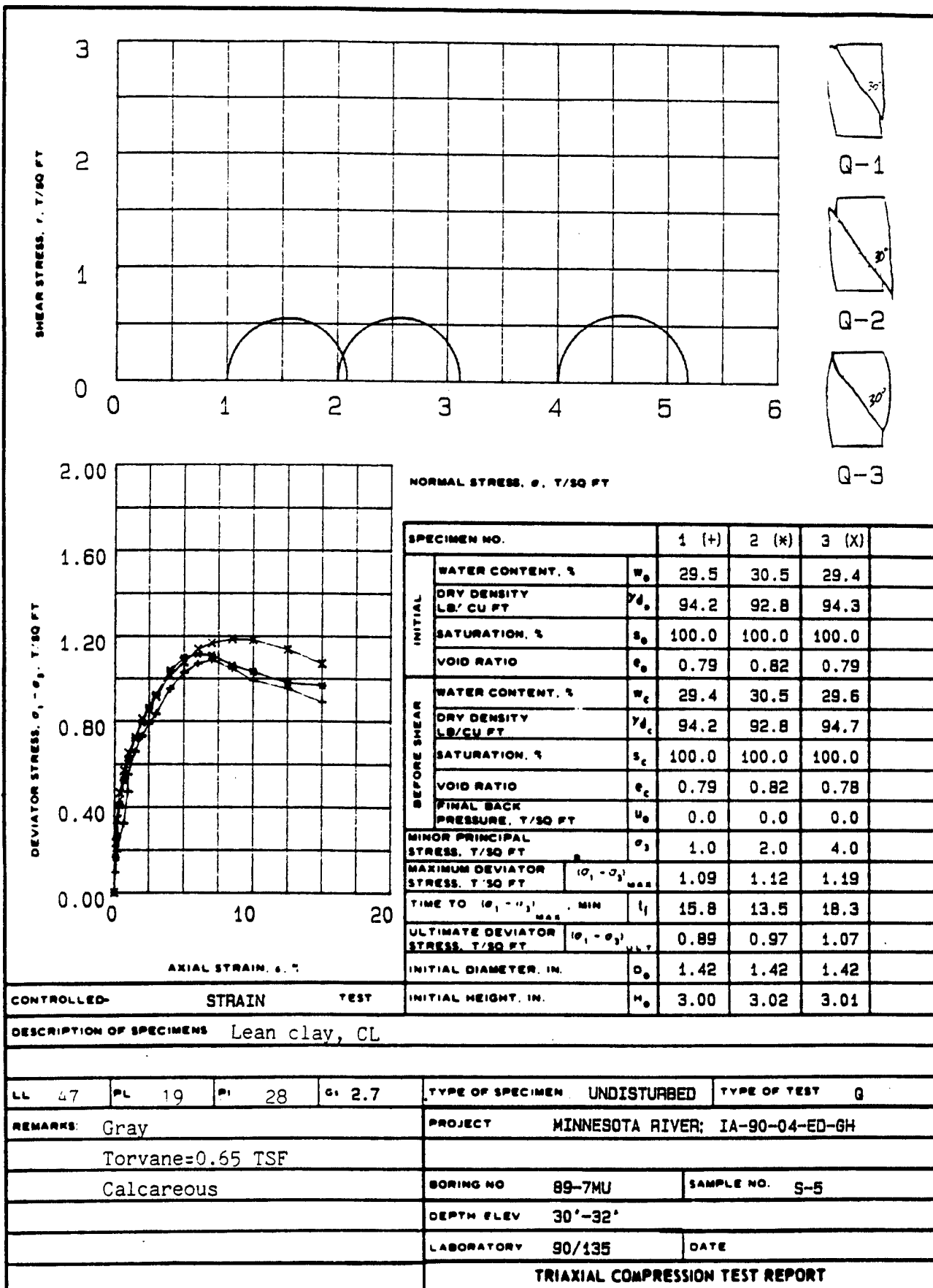
Gs = 2.7

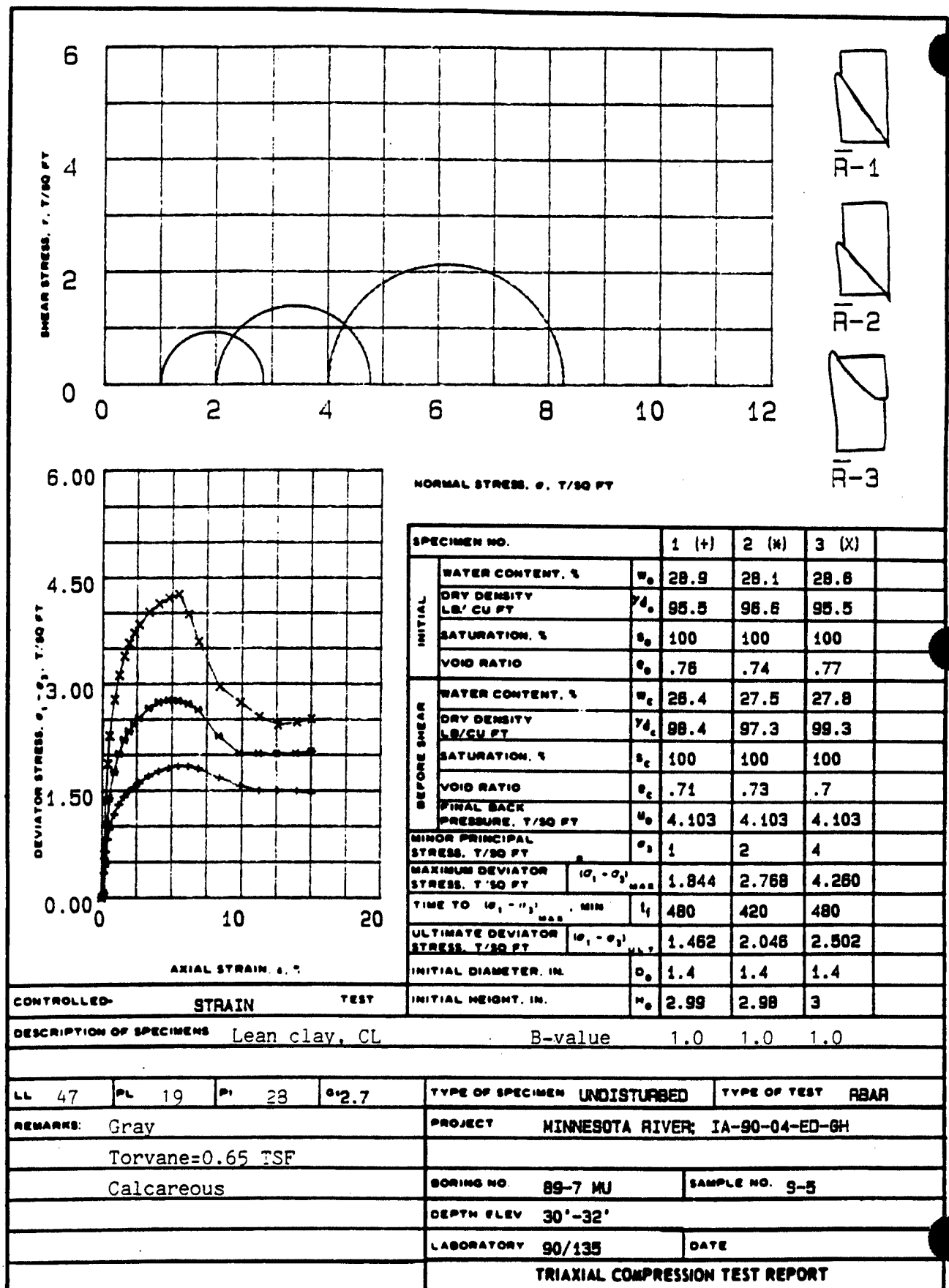
eo = 0.786

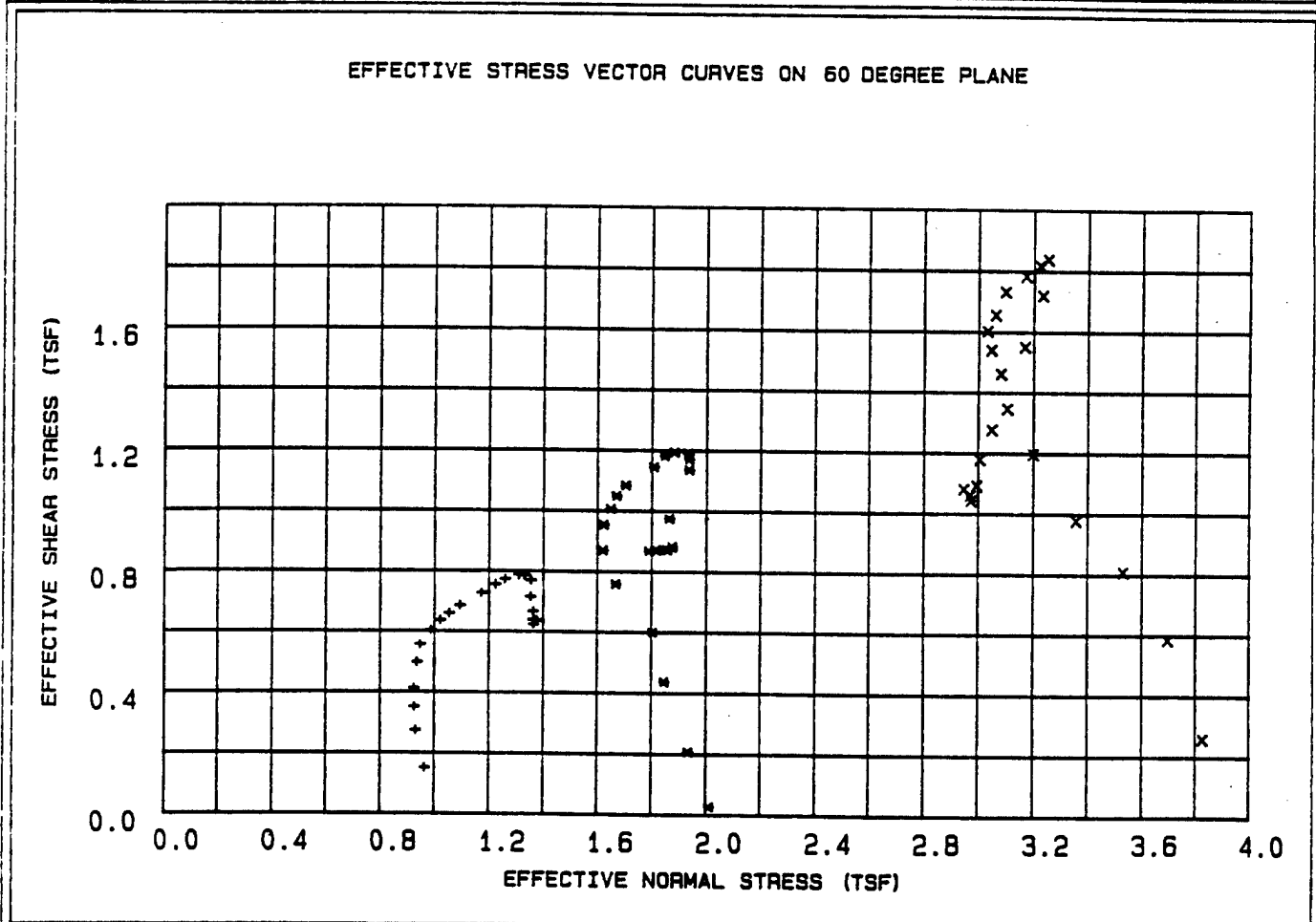
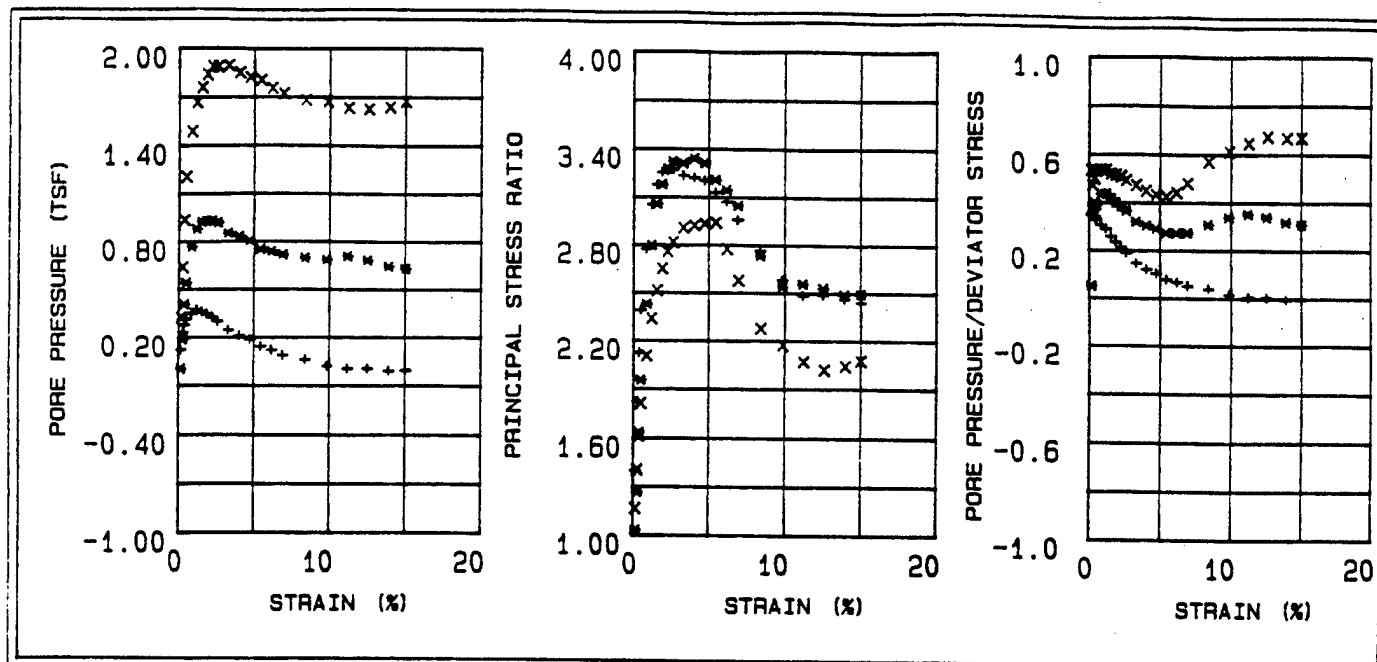
0.42eo = 0.330

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
29.3	383.2	94.3	0.786		100.0
27.9	383.2	94.9	0.774	0.10	97.3
27.9	383.2	95.2	0.770	0.25	97.9
27.9	383.2	95.6	0.763	0.50	98.7
27.9	383.2	96.2	0.751	1.00	100.0
27.9	383.2	97.0	0.737	2.00	100.0
27.9	383.2	98.2	0.715	4.00	100.0
27.9	383.2	100.4	0.678	8.00	100.0
27.9	383.2	99.6	0.691	2.00	100.0
27.9	383.2	98.6	0.709	0.50	100.0
27.9	383.2	97.5	0.728	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.768
2	0.750
3	0.732
4	0.714
5	0.697
6	0.679
7	0.661
8	0.643
9	0.625







<b>LEGEND</b> + = 1 TSF * = 2 TSF x = 4 TSF		<b>PROJECT</b> MINNESOTA RIVER: IA-90-04-ED-6H	
<b>BORING NO.</b> 89-7 MU		<b>SAMPLE NO.</b> S-5	
<b>DEPTH/ELEV</b> 30'-32'		<b>MRD LAB NO.</b> 90/135	

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-5  
 Depth : 30'-32'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.17	0.349	0.122	1.397	0.350	0.964	0.151
30	0.29	0.635	0.228	1.823	0.360	0.929	0.274
45	0.41	0.813	0.277	2.124	0.341	0.924	0.351
60	0.52	0.954	0.313	2.389	0.328	0.923	0.412
90	0.88	1.153	0.350	2.774	0.304	0.935	0.498
120	1.22	1.289	0.372	3.053	0.289	0.947	0.556
150	1.57	1.396	0.359	3.177	0.257	0.987	0.603
180	1.90	1.477	0.345	3.254	0.234	1.021	0.637
210	2.26	1.530	0.325	3.265	0.213	1.054	0.660
240	2.62	1.591	0.300	3.274	0.189	1.094	0.687
300	3.31	1.687	0.245	3.234	0.146	1.173	0.728
360	4.03	1.754	0.210	3.220	0.120	1.224	0.757
420	4.71	1.795	0.185	3.202	0.103	1.259	0.775
480	5.43	1.826	0.142	3.129	0.078	1.310	0.788
540	6.15	1.823	0.120	3.071	0.066	1.331	0.787
600	6.88	1.784	0.088	2.957	0.050	1.354	0.770
720	8.36	1.660	0.060	2.766	0.037	1.351	0.716
840	9.81	1.546	0.021	2.580	0.014	1.362	0.667
960	11.17	1.478	0.004	2.484	0.003	1.362	0.638
1080	12.50	1.482	0.004	2.489	0.003	1.363	0.640
1200	13.89	1.476	-0.010	2.463	-0.006	1.376	0.637
1292	15.00	1.447	-0.005	2.440	-0.003	1.363	0.624



Table 5 - Triaxial  $\bar{R}$  Test Results

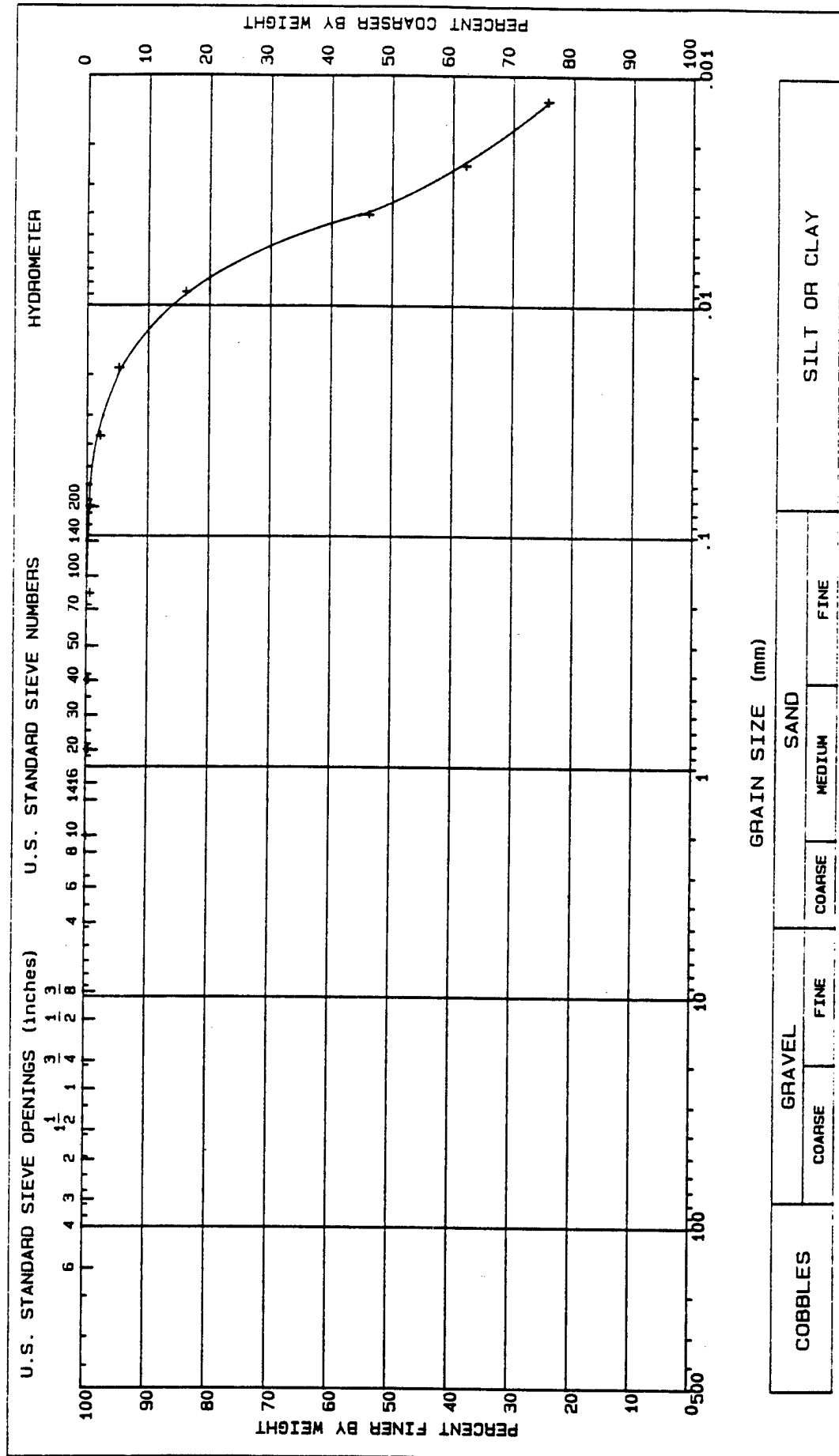
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-5  
 Depth : 30'-32'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.17	0.062	0.003	1.031	0.050	2.012	0.027
30	0.29	0.480	0.184	1.265	0.383	1.935	0.207
45	0.41	1.012	0.405	1.634	0.401	1.846	0.437
60	0.52	1.390	0.541	1.953	0.390	1.803	0.600
90	0.88	1.761	0.768	2.429	0.437	1.668	0.760
120	1.22	2.016	0.879	2.798	0.436	1.620	0.870
150	1.57	2.212	0.925	3.057	0.418	1.623	0.955
180	1.91	2.333	0.929	3.179	0.399	1.649	1.007
210	2.26	2.433	0.932	3.279	0.384	1.670	1.050
240	2.62	2.514	0.919	3.325	0.366	1.703	1.085
300	3.31	2.656	0.851	3.312	0.321	1.807	1.146
360	4.03	2.740	0.831	3.344	0.304	1.847	1.182
420	4.72	2.768	0.802	3.311	0.290	1.883	1.195
480	5.43	2.759	0.750	3.207	0.272	1.933	1.191
540	6.15	2.713	0.736	3.146	0.272	1.936	1.171
600	6.89	2.631	0.715	3.047	0.272	1.936	1.136
720	8.36	2.260	0.695	2.731	0.308	1.864	0.975
840	9.82	2.020	0.685	2.537	0.340	1.815	0.872
960	11.18	2.011	0.708	2.557	0.353	1.790	0.868
1080	12.51	2.017	0.682	2.531	0.339	1.817	0.871
1200	13.89	2.021	0.643	2.489	0.318	1.857	0.872
1291	15.00	2.046	0.631	2.494	0.309	1.875	0.883

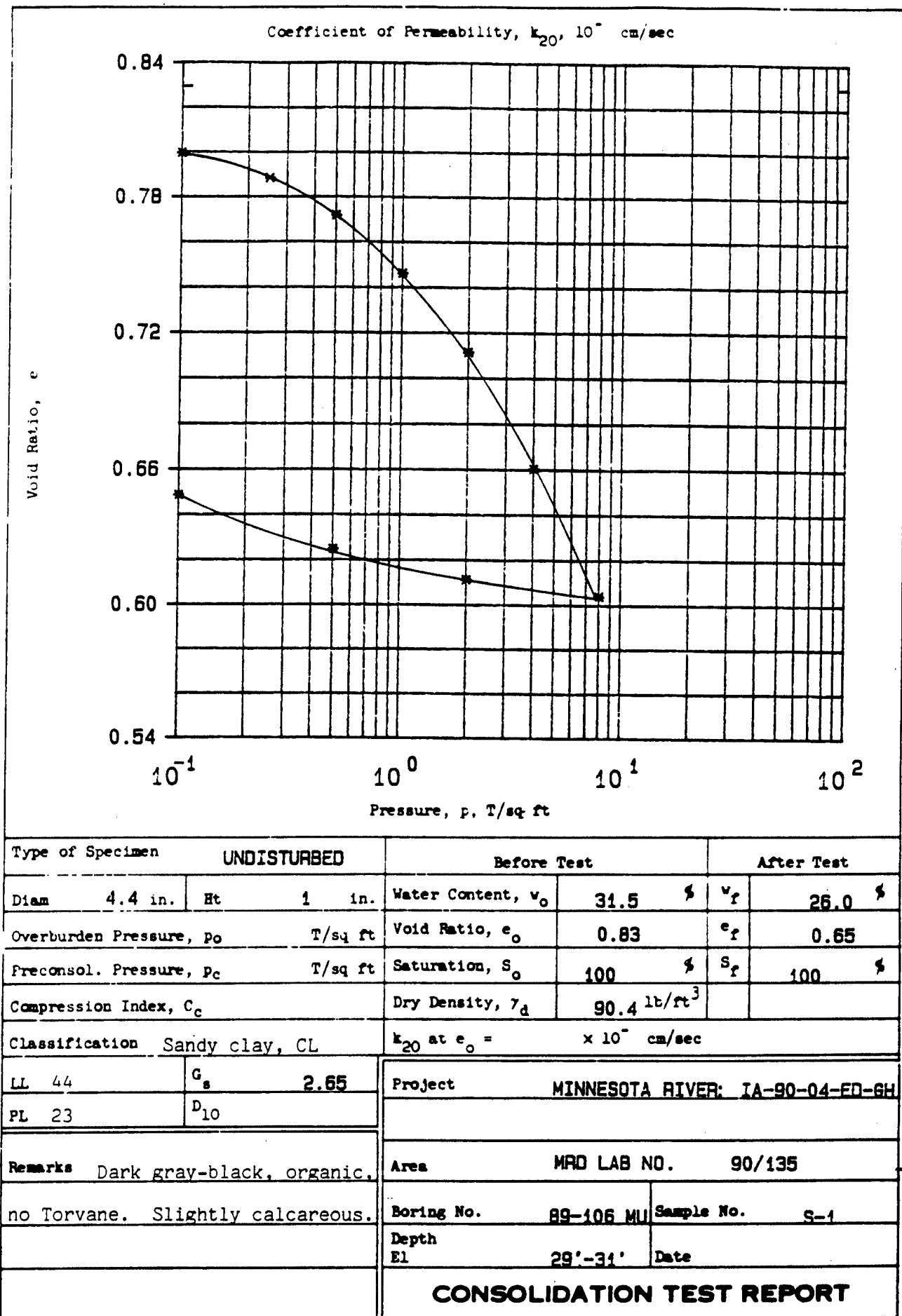
Table 6 - Triaxial  $\bar{R}$  Test Results

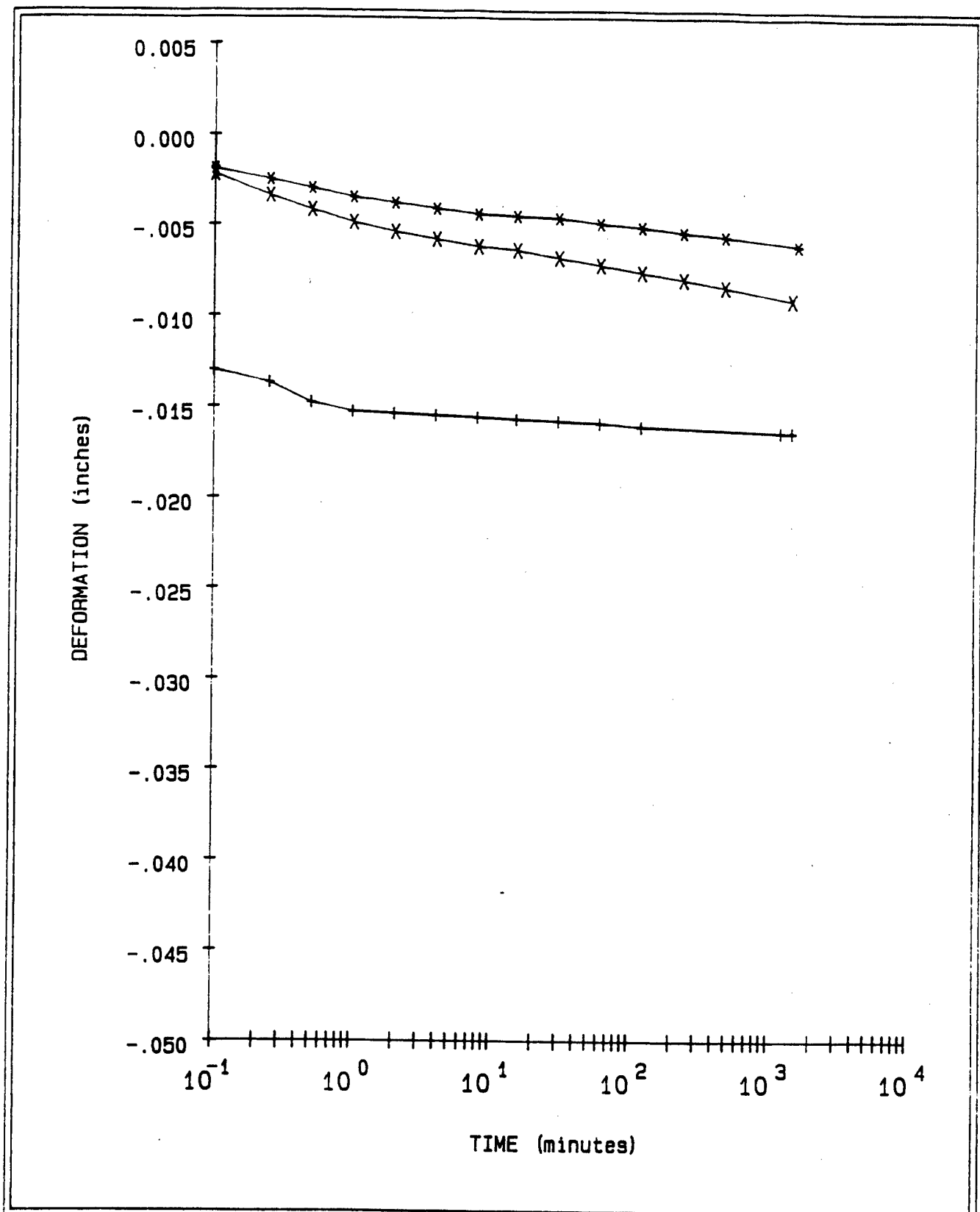
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-7 MU  
 Sample Number : S-5  
 Depth : 30'-32'  
 Confining Pressure : 4 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.17	0.600	0.321	1.163	0.535	3.827	0.259
30	0.29	1.355	0.638	1.403	0.471	3.697	0.585
45	0.41	1.874	0.933	1.611	0.499	3.531	0.809
60	0.53	2.266	1.204	1.811	0.532	3.357	0.978
90	0.89	2.774	1.488	2.104	0.537	3.199	1.197
120	1.22	3.119	1.667	2.337	0.535	3.105	1.346
150	1.58	3.388	1.758	2.512	0.519	3.081	1.462
180	1.92	3.569	1.838	2.650	0.515	3.046	1.540
210	2.28	3.711	1.888	2.757	0.509	3.031	1.602
240	2.64	3.835	1.888	2.815	0.493	3.061	1.655
300	3.33	4.010	1.896	2.906	0.473	3.097	1.731
360	4.05	4.129	1.850	2.921	0.449	3.172	1.782
420	4.74	4.213	1.821	2.933	0.433	3.222	1.818
480	5.46	4.260	1.804	2.940	0.424	3.251	1.838
540	6.18	3.983	1.754	2.773	0.441	3.232	1.719
600	6.93	3.590	1.721	2.575	0.480	3.168	1.550
720	8.41	2.955	1.683	2.276	0.570	3.049	1.276
840	9.87	2.730	1.671	2.172	0.612	3.005	1.178
960	11.24	2.531	1.633	2.069	0.646	2.994	1.092
1080	12.58	2.416	1.625	2.017	0.673	2.973	1.043
1200	13.97	2.456	1.638	2.040	0.667	2.970	1.060
1284	15.00	2.502	1.673	2.075	0.669	2.946	1.080



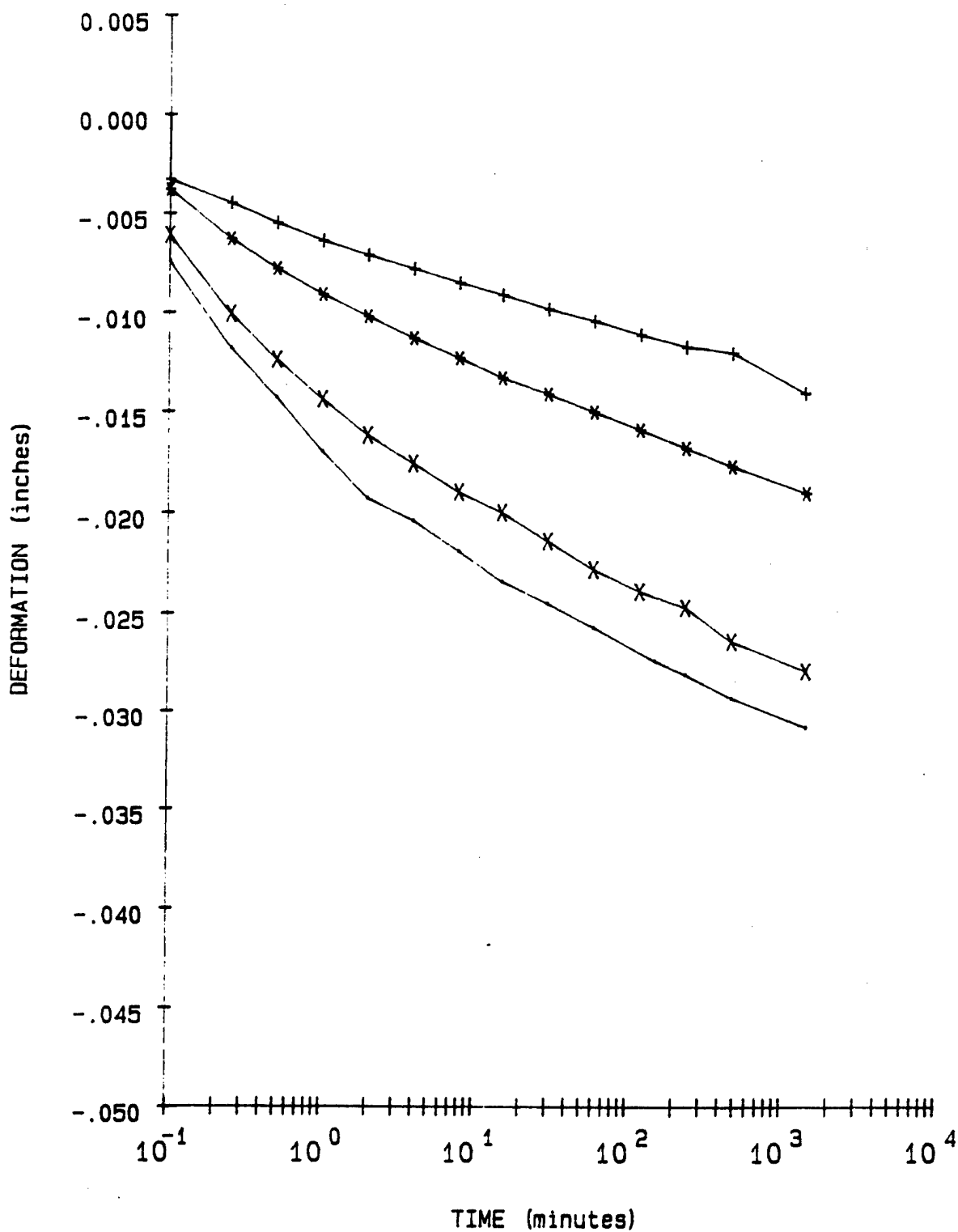
LL - 47	PL - 19	PI - 28	Gs - 2.7	NAT W -	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
CLASSIFICATION Lean clay, CL						BORING NO.	89-7 MU
						SAMPLE NO.	S-5
						DEPTH/ELEV	30'-32'
						MRD LAB NO.	90/135
GRADATION CURVE							





<b>LEGEND</b> + = .1 TSF * = .25 TSF x = .5 TSF		<b>PROJECT</b> MINNESOTA RIVER: IA-90-04-ED-GH	
		<b>BORING NO.</b> 89-108 MU	
		<b>SAMPLE NO.</b> S-1	
		<b>DEPTH/ELEV</b> 29'-31'	
		<b>MRD LAB NO.</b> 90/135	

FIGURE 18



**LEGEND**

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

**PROJECT**

MINNESOTA RIVER: IA-90-04-ED-GH

**BORING NO.**

89-106 MU

**SAMPLE NO.**

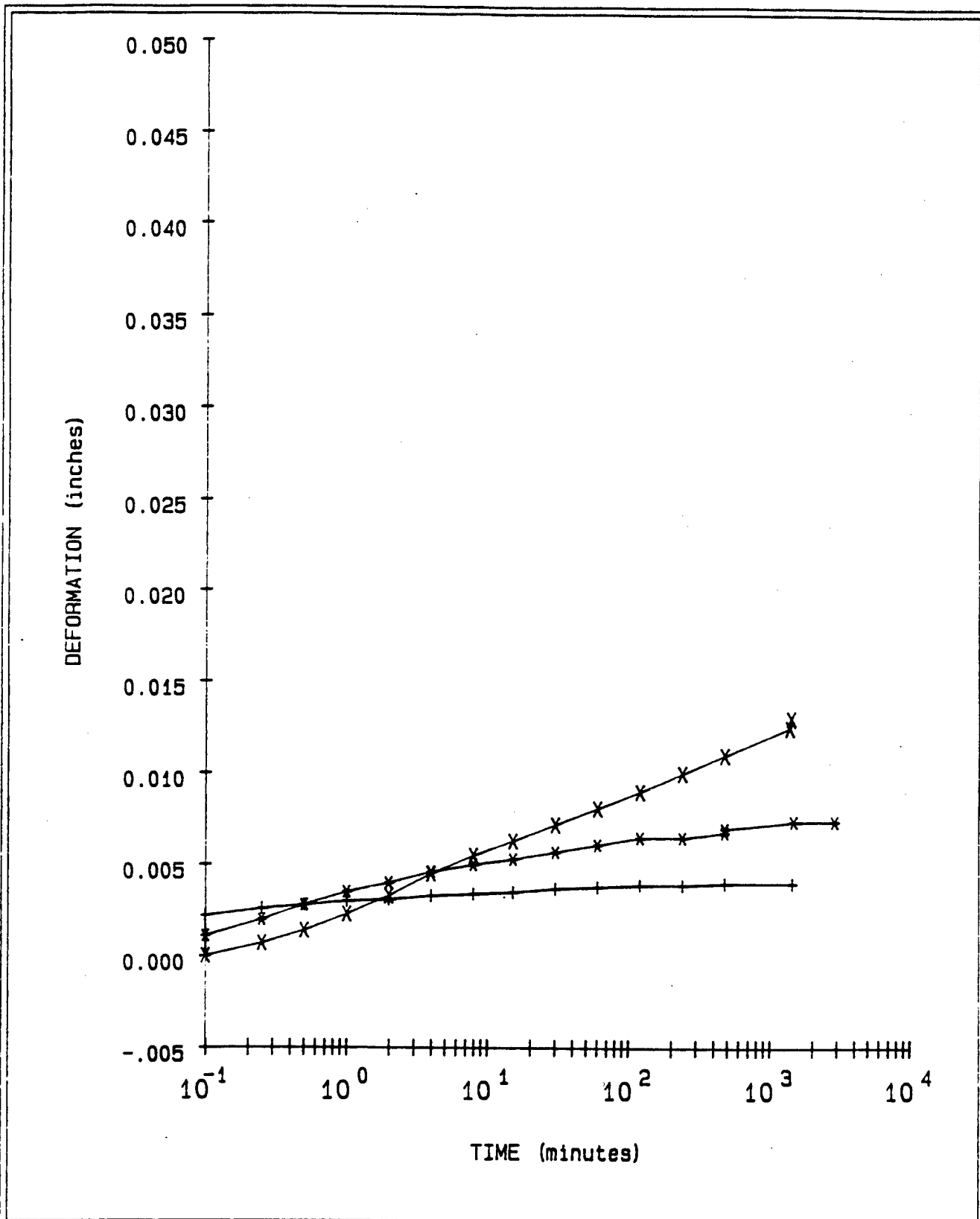
S-1

**DEPTH/ELEV**

29'-31'

**MRD LAB NO.**

90/135



LEGEND	
+	2 TSF Rebound
*	.5 TSF Rebound
x	.1 TSF Rebound

PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
BORING NO.	89-106 MU
SAMPLE NO.	S-1
DEPTH/ELEV	29'-31'
MRD LAB NO.	90/135

FIGURE 20

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-106 MU

Sample No. S-1

Depth/Elev 29'-31'

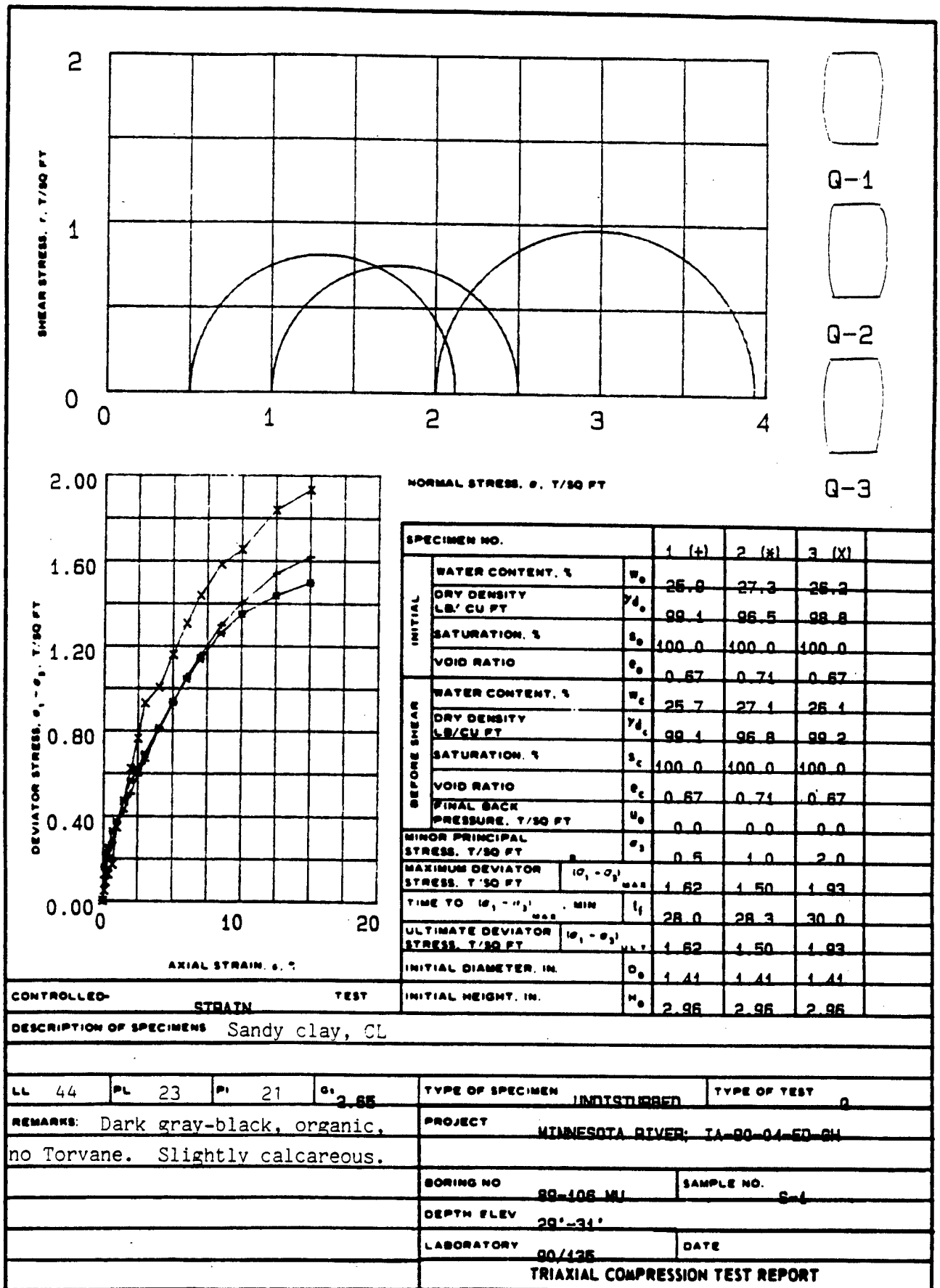
MRD Lab No. 90/135

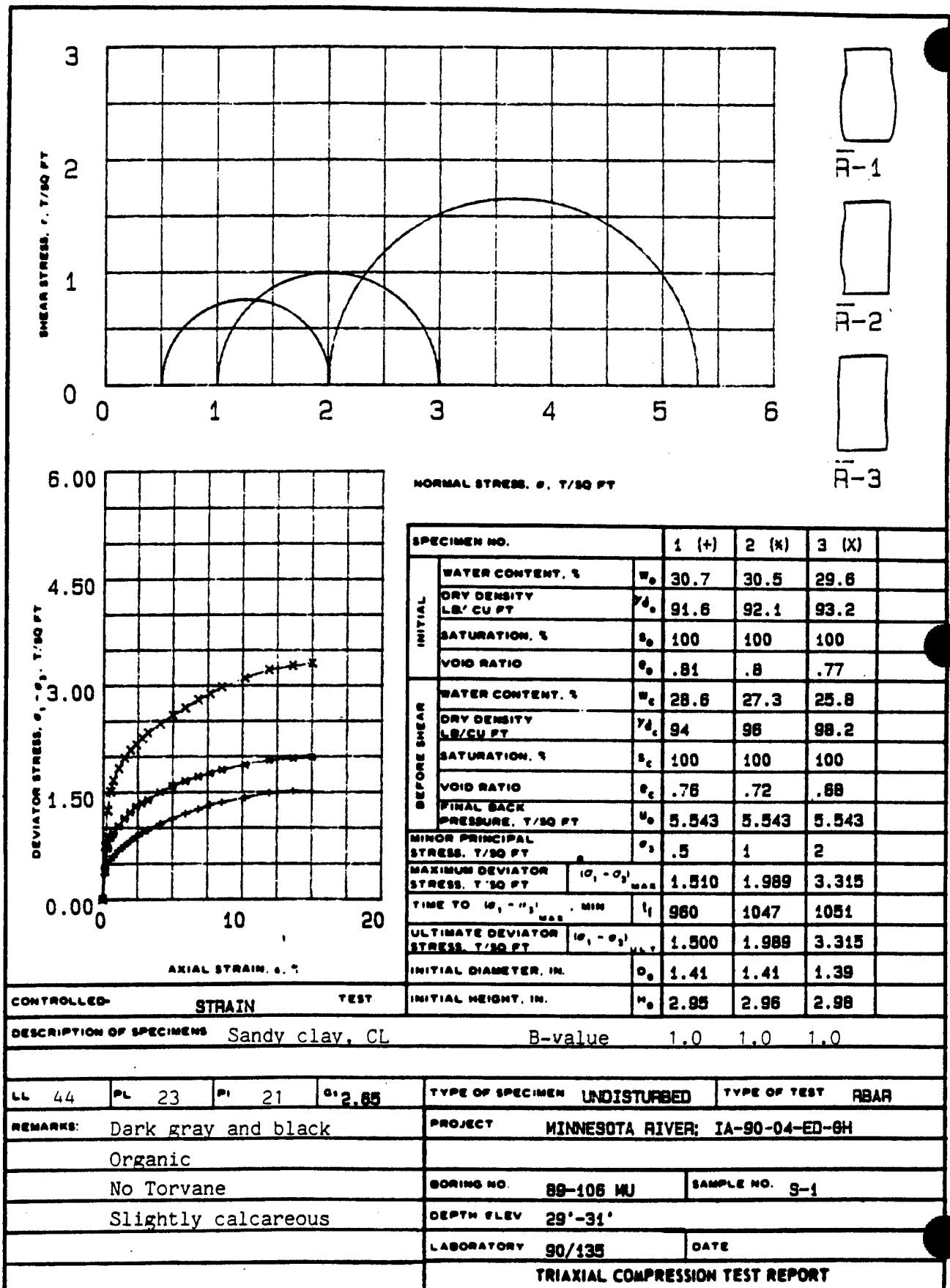
Gs = 2.65  
eo = 0.829  
0.42eo = 0.348

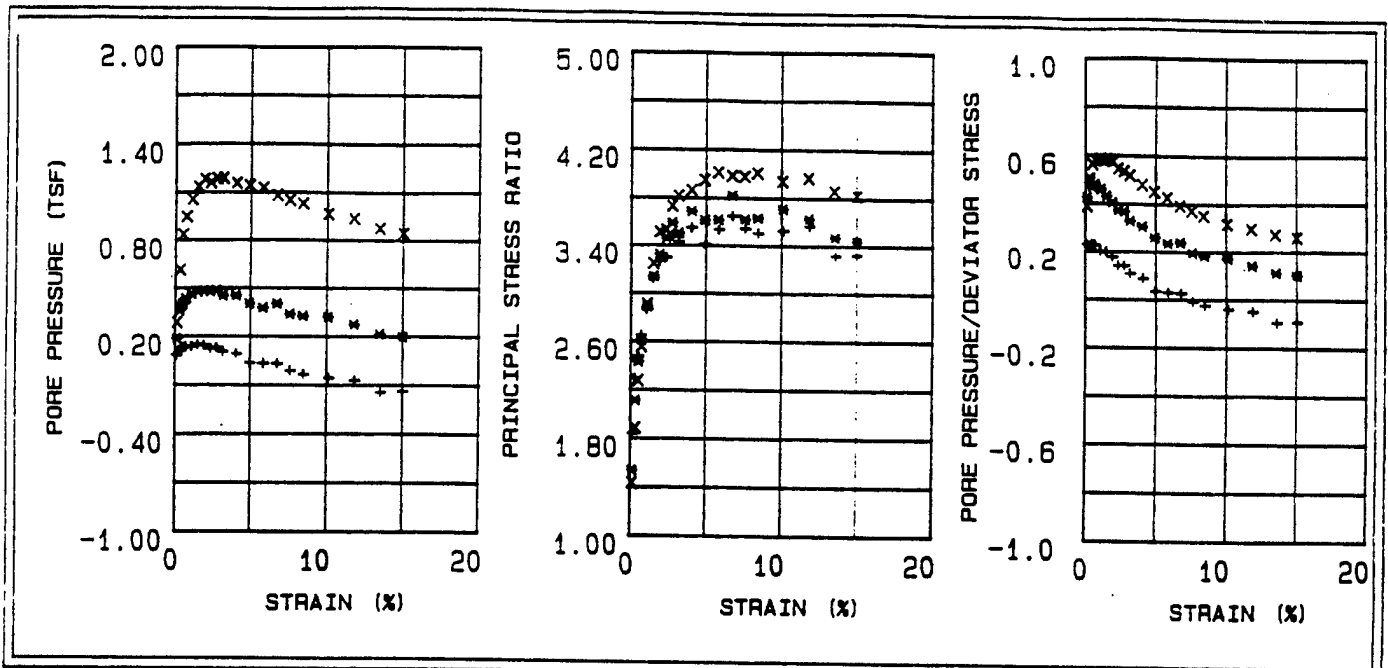
Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
31.5	367.2	90.4	0.829		100.0
26.0	367.2	91.9	0.799	0.10	86.2
26.0	367.2	92.5	0.788	0.25	87.4
26.0	367.2	93.3	0.772	0.50	89.3
26.0	367.2	94.7	0.746	1.00	92.3
26.0	367.2	96.6	0.711	2.00	96.8
26.0	367.2	99.6	0.660	4.00	100.0
26.0	367.2	103.1	0.604	8.00	100.0
26.0	367.2	102.6	0.611	2.00	100.0
26.0	367.2	101.8	0.625	0.50	100.0
26.0	367.2	100.3	0.649	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.811
2	0.793
3	0.775
4	0.756
5	0.738
6	0.720
7	0.701
8	0.683
9	0.665
10	0.647
11	0.628
12	0.610
13	0.592
14	0.573
15	0.555

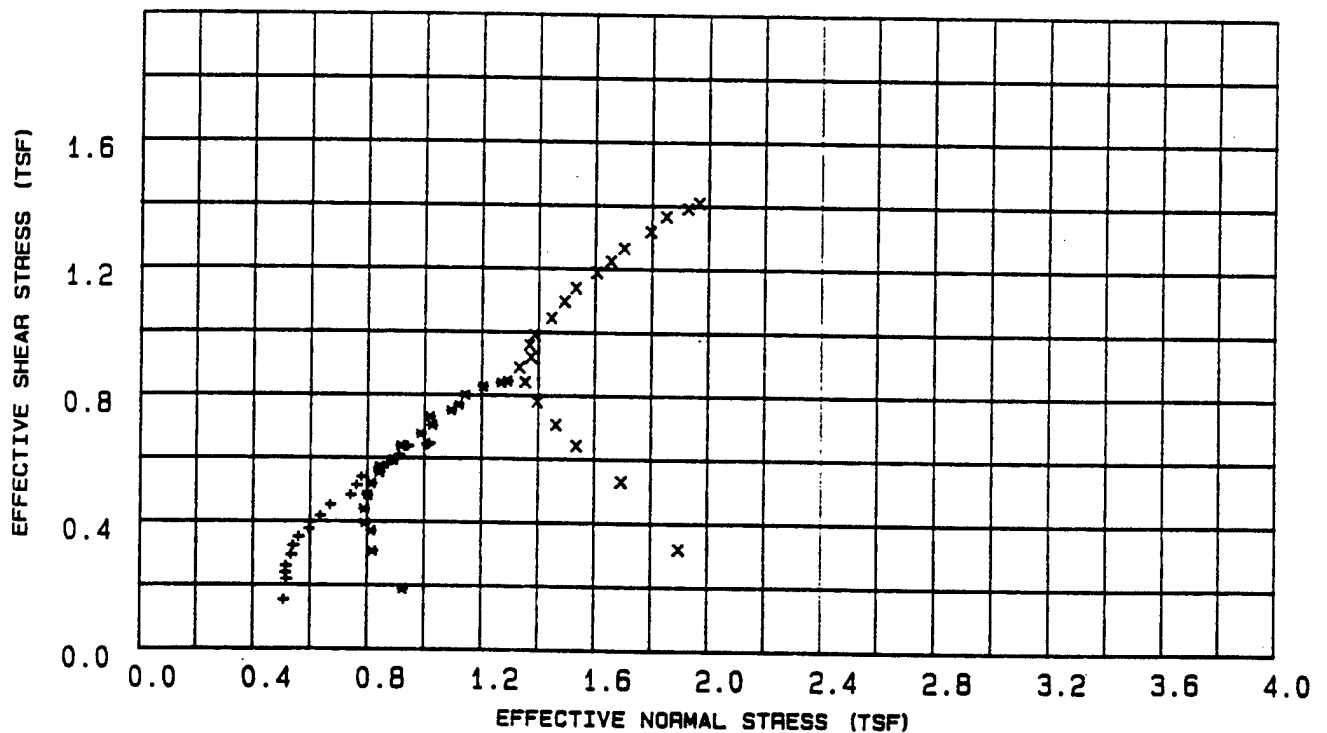








EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-106 MU

SAMPLE NO.

S-1

DEPTH/ELEV

29'-31'

MRD LAB NO.

90/135

Table 7 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-106 MU  
 Sample Number : S-1  
 Depth : 29'-31'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.15	0.351	0.080	1.836	0.227	0.507	0.152
30	0.34	0.503	0.109	2.289	0.218	0.516	0.217
45	0.54	0.552	0.125	2.473	0.227	0.512	0.238
60	0.73	0.600	0.135	2.644	0.225	0.514	0.259
90	1.12	0.680	0.135	2.861	0.199	0.533	0.293
120	1.53	0.749	0.146	3.120	0.196	0.540	0.323
150	1.95	0.810	0.142	3.264	0.176	0.559	0.350
180	2.36	0.870	0.121	3.296	0.140	0.594	0.375
210	2.78	0.921	0.128	3.479	0.140	0.600	0.397
240	3.19	0.963	0.103	3.426	0.107	0.635	0.416
300	4.07	1.046	0.089	3.545	0.086	0.670	0.451
360	4.95	1.118	0.035	3.404	0.032	0.742	0.482
420	5.85	1.188	0.031	3.532	0.026	0.763	0.51
480	6.77	1.248	0.029	3.647	0.023	0.780	0.539
540	7.60	1.309	-0.015	3.541	-0.011	0.839	0.565
600	8.46	1.343	-0.037	3.501	-0.027	0.870	0.580
720	10.11	1.412	-0.059	3.524	-0.042	0.909	0.609
840	11.84	1.474	-0.075	3.562	-0.051	0.940	0.636
960	13.55	1.496	-0.146	3.314	-0.097	1.016	0.646
1054	15.00	1.485	-0.140	3.322	-0.094	1.007	0.641

Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-106 MU  
 Sample Number : S-1  
 Depth : 29'-31'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.15	0.434	0.184	1.532	0.423	0.924	0.187
30	0.34	0.712	0.358	2.110	0.504	0.818	0.307
45	0.54	0.858	0.399	2.428	0.465	0.813	0.370
60	0.73	0.911	0.434	2.608	0.477	0.791	0.393
90	1.12	1.015	0.462	2.887	0.456	0.789	0.438
120	1.53	1.117	0.477	3.138	0.428	0.800	0.482
150	1.94	1.201	0.483	3.324	0.403	0.814	0.518
180	2.36	1.283	0.477	3.455	0.372	0.841	0.554
210	2.77	1.329	0.486	3.587	0.367	0.843	0.573
240	3.18	1.374	0.450	3.499	0.328	0.890	0.593
300	4.05	1.479	0.449	3.683	0.304	0.917	0.638
360	4.93	1.564	0.401	3.609	0.257	0.986	0.675
420	5.83	1.629	0.376	3.613	0.232	1.027	0.703
480	6.75	1.692	0.401	3.822	0.237	1.018	0.730
540	7.58	1.738	0.336	3.617	0.194	1.094	0.750
600	8.43	1.783	0.322	3.630	0.181	1.119	0.769
720	10.08	1.852	0.316	3.709	0.171	1.143	0.800
840	11.80	1.916	0.270	3.623	0.141	1.204	0.827
960	13.50	1.943	0.212	3.467	0.110	1.269	0.839
1057	15.00	1.959	0.195	3.435	0.100	1.290	0.846

Table 9 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-106 MU  
 Sample Number : S-1  
 Depth : 29'-31'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.15	0.736	0.283	1.429	0.386	1.899	0.318
30	0.34	1.226	0.610	1.882	0.498	1.694	0.529
45	0.53	1.486	0.833	2.273	0.561	1.535	0.641
60	0.73	1.639	0.944	2.552	0.577	1.462	0.707
90	1.12	1.804	1.053	2.906	0.584	1.394	0.779
120	1.52	1.949	1.131	3.244	0.581	1.352	0.841
150	1.94	2.059	1.179	3.508	0.573	1.331	0.888
180	2.35	2.132	1.156	3.527	0.543	1.372	0.920
210	2.76	2.222	1.184	3.725	0.533	1.366	0.959
240	3.17	2.295	1.184	3.813	0.517	1.384	0.990
300	4.04	2.418	1.154	3.860	0.478	1.445	1.044
360	4.91	2.539	1.138	3.946	0.449	1.491	1.096
420	5.81	2.640	1.123	4.010	0.426	1.531	1.139
480	6.73	2.754	1.077	3.982	0.391	1.605	1.18
540	7.55	2.836	1.047	3.975	0.370	1.655	1.224
600	8.40	2.931	1.025	4.007	0.350	1.701	1.265
720	10.05	3.053	0.961	3.937	0.315	1.795	1.318
840	11.76	3.164	0.933	3.964	0.295	1.850	1.366
960	13.46	3.224	0.871	3.856	0.271	1.927	1.392
1060	15.00	3.264	0.842	3.819	0.258	1.966	1.409

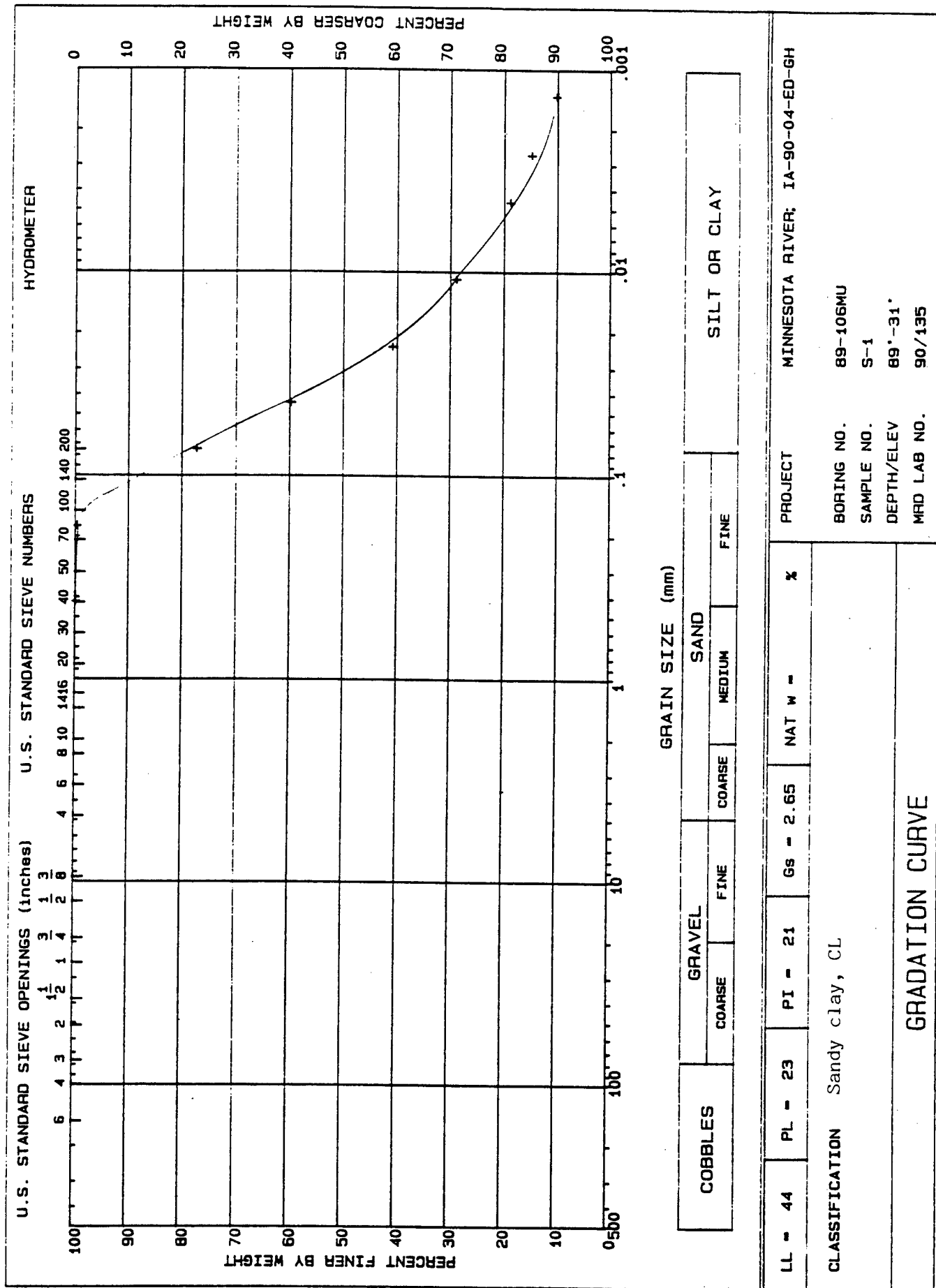
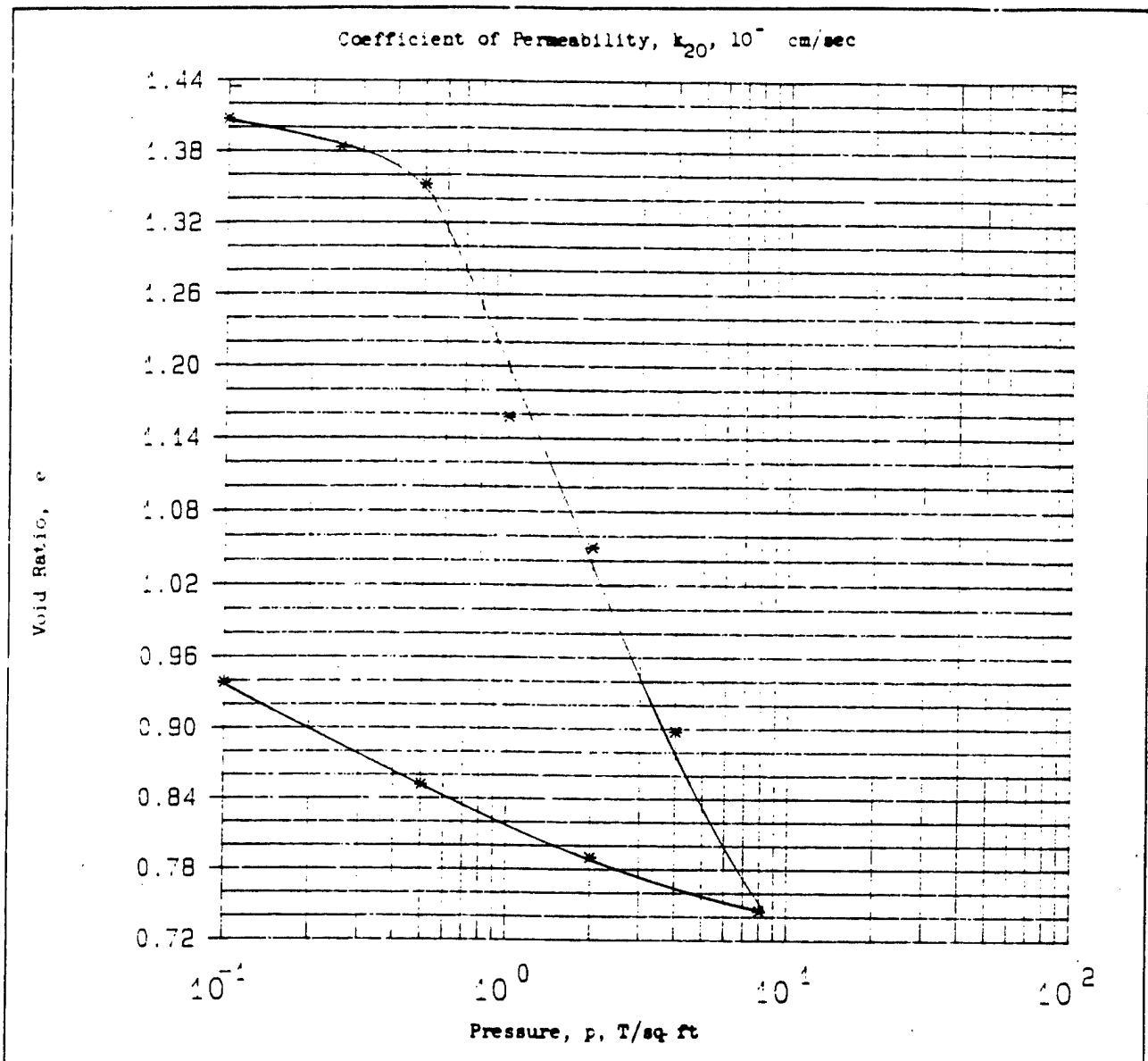
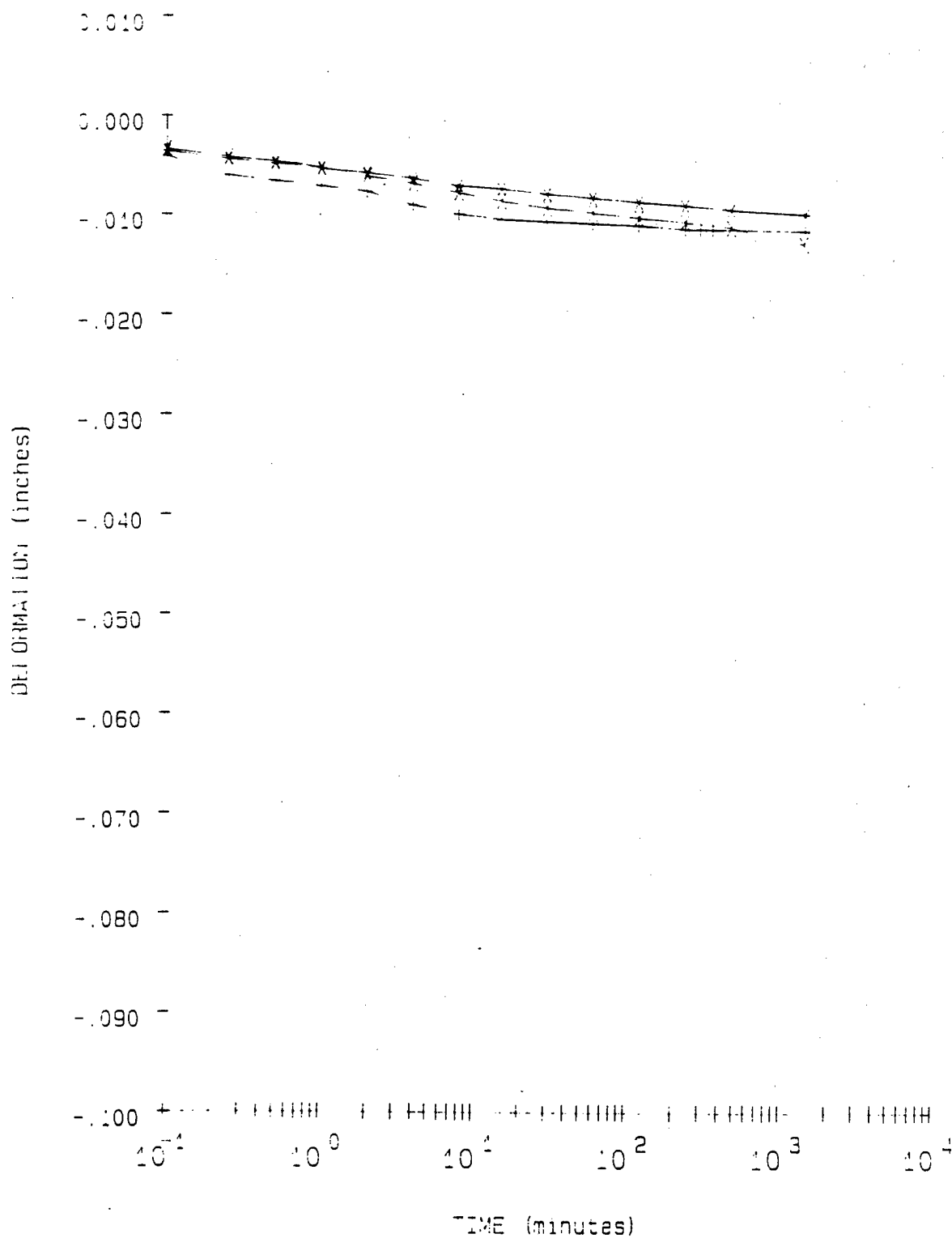


FIGURE 24

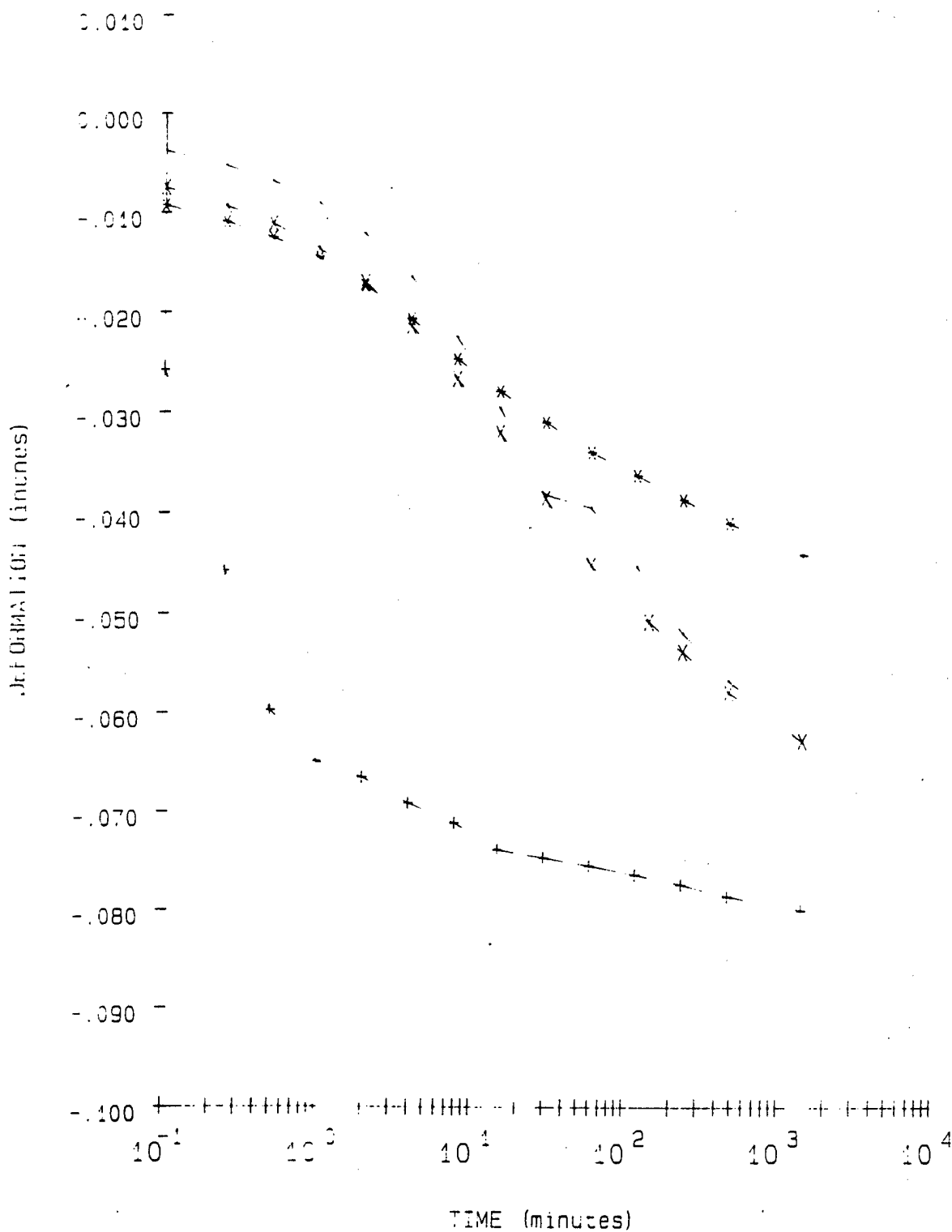


Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	1 in.	Water Content, $w_o$	59.1 %	$w_f$	48.1 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	1.43	$e_f$	0.94
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	100 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	62.8 lb/ft <sup>3</sup>		
Classification Fat clay, CH				$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec			
LL	26	$G_s$	2.45	Project MINNESOTA RIVER: IA-90-04-ED-GH			
PL	37	$D_{10}$					
Remarks Black				Area MRD LAB NO. 90/135			
Slightly organic				Boring No.	89-106MU	Sample No.	S-2
No Torvane				Depth El	32'-34'	Date	
Non-calcareous				CONSOLIDATION TEST REPORT			



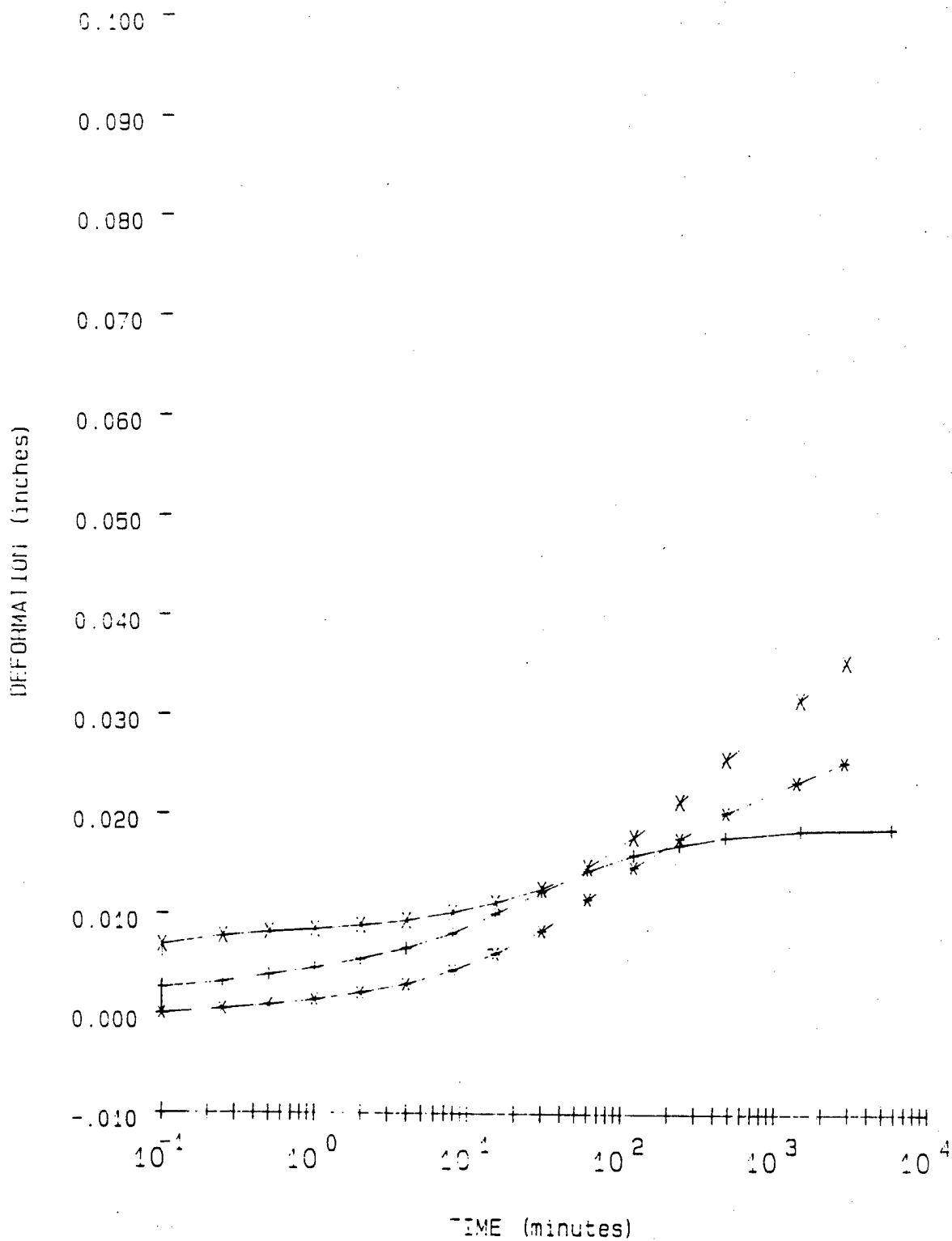


<b>LEGEND</b> - = .1 TSF + = .25 TSF * = .5 TSF	<b>PROJECT</b>	MINNESOTA RIVER; IA-90-04-ED-GH
	<b>BORING NO.</b>	89-106MU
	<b>SAMPLE NO.</b>	S-2
	<b>DEPTH/ELEV</b>	32'-34'
	<b>MRD LAB NO.</b>	90/135



LEGEND		PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
+	1 TSF	BORING NO.	89-106MU
*	2 TSF	SAMPLE NO.	S-2
x	4 TSF	DEPTH/ELEV	32'-34'
-	8 TSF	MRD LAB NO.	90/135

FIGURE 27



LEGEND  
 + = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT MINNESOTA RIVER; IA-90-04-ED-GH  
 BORING NO. 89-106MU  
 SAMPLE NO. S-2  
 DEPTH/ELEV 32'-34'  
 MRD LAB NO. 90/135

FIGURE 28

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-106MU

Sample No. S-2

Depth/Elev 32'-34'

MRD Lab No. 90/135

Gs = 2.45

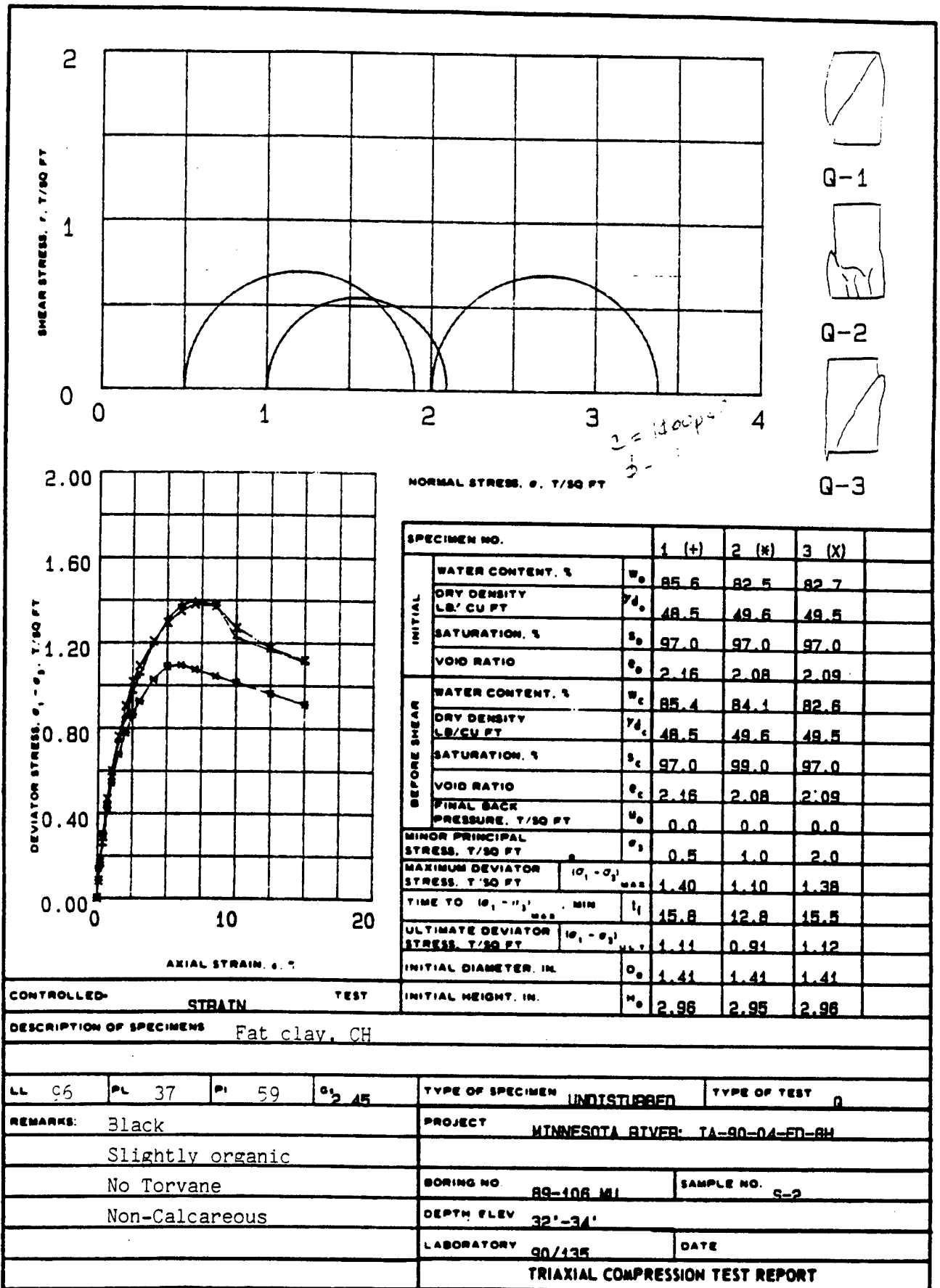
eo = 1.435

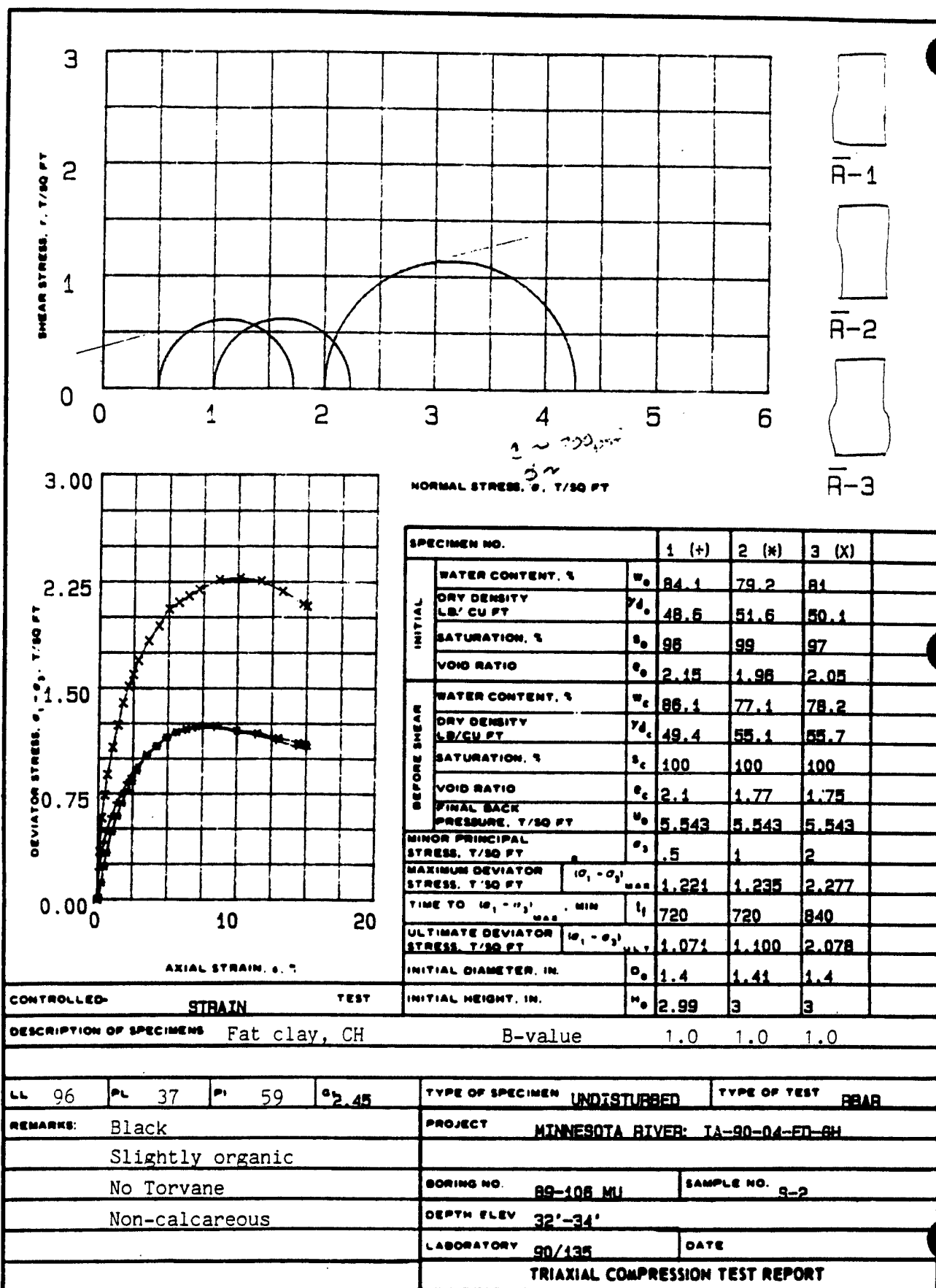
0.42eo = 0.603

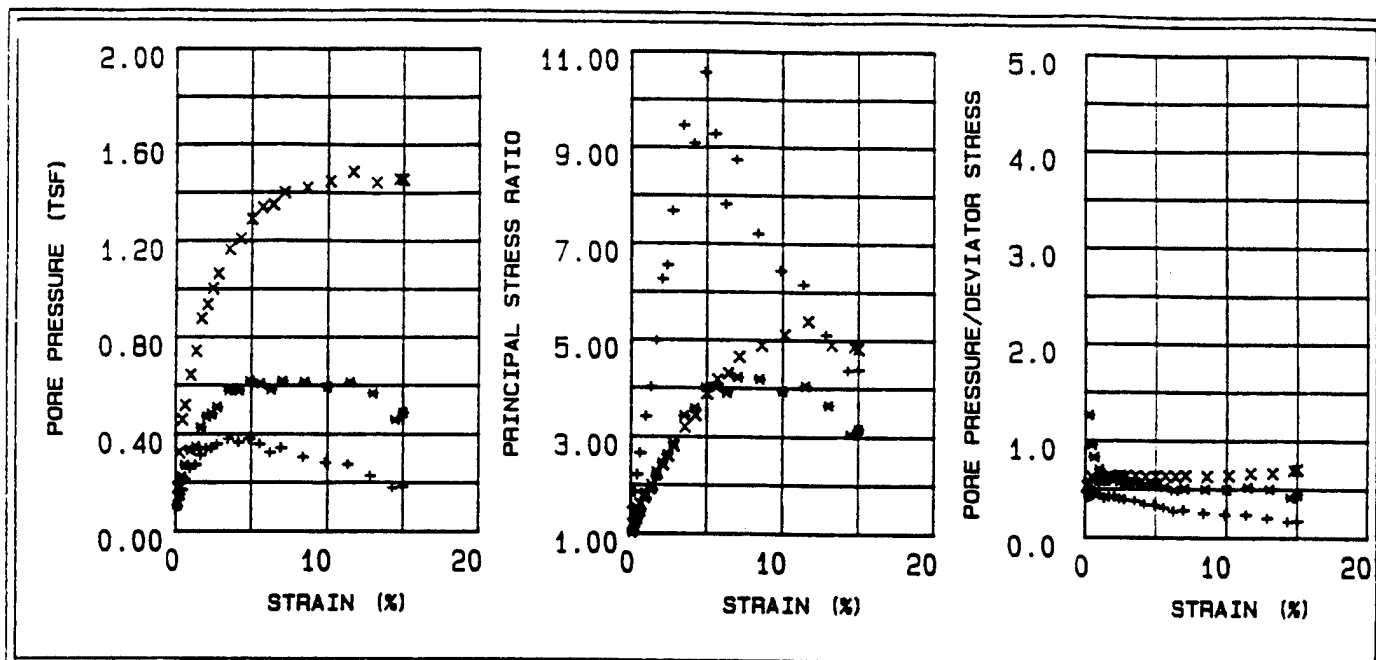
Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
59.1	236.0	62.8	1.435		100.0
48.1	236.0	63.5	1.407	0.10	83.8
48.1	236.0	64.1	1.383	0.25	85.2
48.1	236.0	65.0	1.352	0.50	87.2
48.1	236.0	70.9	1.158	1.00	100.0
48.1	236.0	74.6	1.050	2.00	100.0
48.1	236.0	80.6	0.897	4.00	100.0
48.1	236.0	87.6	0.744	8.00	100.0
48.1	236.0	85.4	0.790	2.00	100.0
48.1	236.0	82.6	0.852	0.50	100.0
48.1	236.0	78.9	0.938	0.10	100.0

Axial Strain (%)      Void Ratio

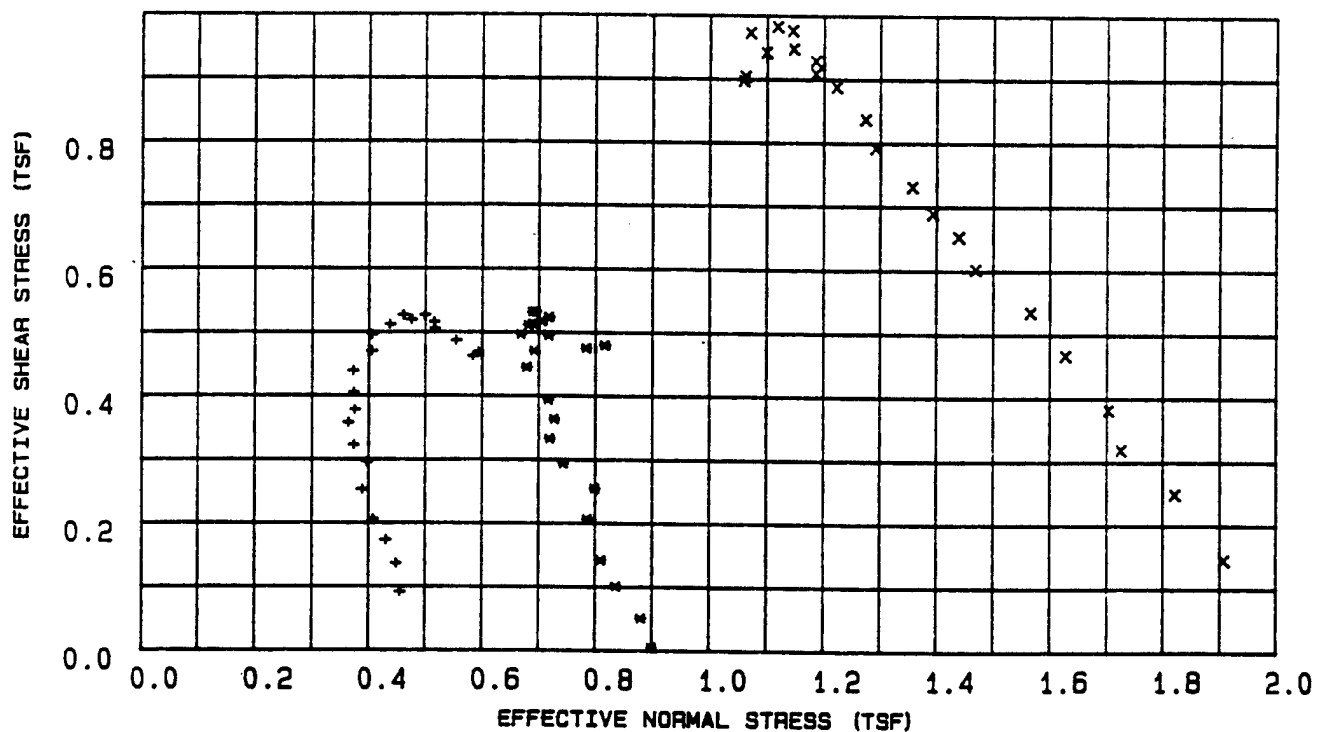
1	1.410
2	1.386
3	1.362
4	1.337
5	1.313
6	1.288
7	1.264
8	1.240
9	1.215
10	1.191
11	1.167
12	1.142
13	1.118
14	1.094
15	1.069
16	1.045
17	1.021
18	0.996
19	0.972
20	0.948







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

- + = .5 TSF
- \* = 1 TSF
- x = 2 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO.

89-106 MU

SAMPLE NO.

S-2

DEPTH/ELEV

32'-34'

MRD LAB NO.

90/135

Table 10 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-106 MU  
 Sample Number : S-2  
 Depth : 32'-34'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.210	0.097	1.521	0.461	0.455	0.091
30	0.29	0.314	0.130	1.849	0.414	0.448	0.136
45	0.47	0.400	0.169	2.208	0.423	0.430	0.173
60	0.64	0.477	0.211	2.649	0.443	0.407	0.206
90	1.00	0.586	0.257	3.410	0.439	0.388	0.253
120	1.35	0.685	0.273	4.015	0.399	0.397	0.296
150	1.69	0.749	0.312	4.981	0.417	0.373	0.323
180	2.07	0.829	0.342	6.254	0.413	0.363	0.358
210	2.40	0.875	0.342	6.545	0.391	0.375	0.378
240	2.75	0.938	0.359	7.673	0.384	0.373	0.405
300	3.47	1.018	0.380	9.462	0.373	0.372	0.439
360	4.16	1.089	0.365	9.083	0.336	0.405	0.470
420	4.87	1.150	0.380	10.561	0.331	0.405	0.496
480	5.56	1.186	0.357	9.267	0.301	0.437	0.512
540	6.25	1.204	0.323	7.815	0.269	0.475	0.520
600	6.96	1.221	0.342	8.734	0.281	0.460	0.527
720	8.38	1.221	0.303	7.204	0.249	0.499	0.527
840	9.86	1.196	0.280	6.436	0.235	0.516	0.516
960	11.33	1.170	0.273	6.151	0.234	0.517	0.505
1080	12.83	1.128	0.225	5.105	0.200	0.554	0.487
1200	14.28	1.088	0.176	4.358	0.162	0.593	0.469
1261	15.00	1.071	0.183	4.379	0.171	0.583	0.462



Table - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-106 MU  
 Sample Number : S-2  
 Depth : 32'-34'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.011	0.104	1.013	9.054	0.899	0.005
30	0.29	0.118	0.149	1.139	1.261	0.880	0.051
45	0.48	0.234	0.222	1.300	0.952	0.836	0.101
60	0.65	0.329	0.271	1.452	0.825	0.810	0.142
90	1.01	0.480	0.333	1.720	0.695	0.786	0.207
120	1.37	0.591	0.347	1.906	0.588	0.799	0.255
150	1.71	0.682	0.426	2.189	0.625	0.743	0.294
180	2.09	0.772	0.472	2.463	0.612	0.719	0.333
210	2.43	0.843	0.482	2.628	0.573	0.727	0.364
240	2.79	0.913	0.510	2.864	0.560	0.716	0.394
300	3.52	1.031	0.577	3.435	0.559	0.678	0.445
360	4.21	1.092	0.578	3.588	0.530	0.692	0.471
420	4.94	1.152	0.617	4.010	0.536	0.668	0.497
480	5.63	1.192	0.606	4.026	0.509	0.689	0.514
540	6.33	1.213	0.582	3.903	0.480	0.718	0.524
600	7.05	1.233	0.617	4.222	0.501	0.688	0.532
720	8.50	1.235	0.612	4.182	0.496	0.694	0.533
840	9.99	1.200	0.591	3.932	0.492	0.706	0.518
960	11.48	1.183	0.612	4.046	0.518	0.681	0.511
1080	13.00	1.147	0.567	3.647	0.495	0.717	0.495
1200	14.47	1.113	0.458	3.054	0.412	0.817	0.480
1245	15.00	1.100	0.488	3.159	0.444	0.784	0.475

Table 12 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-106 MU  
 Sample Number : S-2  
 Depth : 32'-34'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.336	0.176	1.184	0.523	1.907	0.145
30	0.29	0.576	0.322	1.343	0.559	1.821	0.249
45	0.49	0.740	0.458	1.480	0.620	1.725	0.319
60	0.66	0.885	0.517	1.597	0.585	1.702	0.382
90	1.03	1.081	0.641	1.796	0.594	1.627	0.467
120	1.39	1.239	0.741	1.984	0.599	1.566	0.535
150	1.74	1.396	0.877	2.243	0.629	1.469	0.602
180	2.13	1.514	0.936	2.423	0.619	1.439	0.653
210	2.47	1.596	1.002	2.599	0.628	1.393	0.689
240	2.84	1.694	1.062	2.807	0.627	1.357	0.731
300	3.57	1.835	1.162	3.190	0.633	1.292	0.792
360	4.28	1.939	1.206	3.443	0.622	1.274	0.837
420	5.01	2.058	1.288	3.890	0.626	1.222	0.888
480	5.72	2.105	1.336	4.170	0.635	1.185	0.901
540	6.43	2.152	1.348	4.301	0.627	1.185	0.929
600	7.16	2.196	1.398	4.648	0.637	1.146	0.948
720	8.63	2.265	1.417	4.888	0.626	1.144	0.977
840	10.15	2.277	1.446	5.110	0.636	1.118	0.983
960	11.66	2.255	1.487	5.393	0.660	1.071	0.973
1080	13.21	2.182	1.441	4.900	0.661	1.099	0.942
1200	14.70	2.095	1.457	4.856	0.696	1.062	0.904
1225	15.00	2.078	1.455	4.816	0.701	1.059	0.897

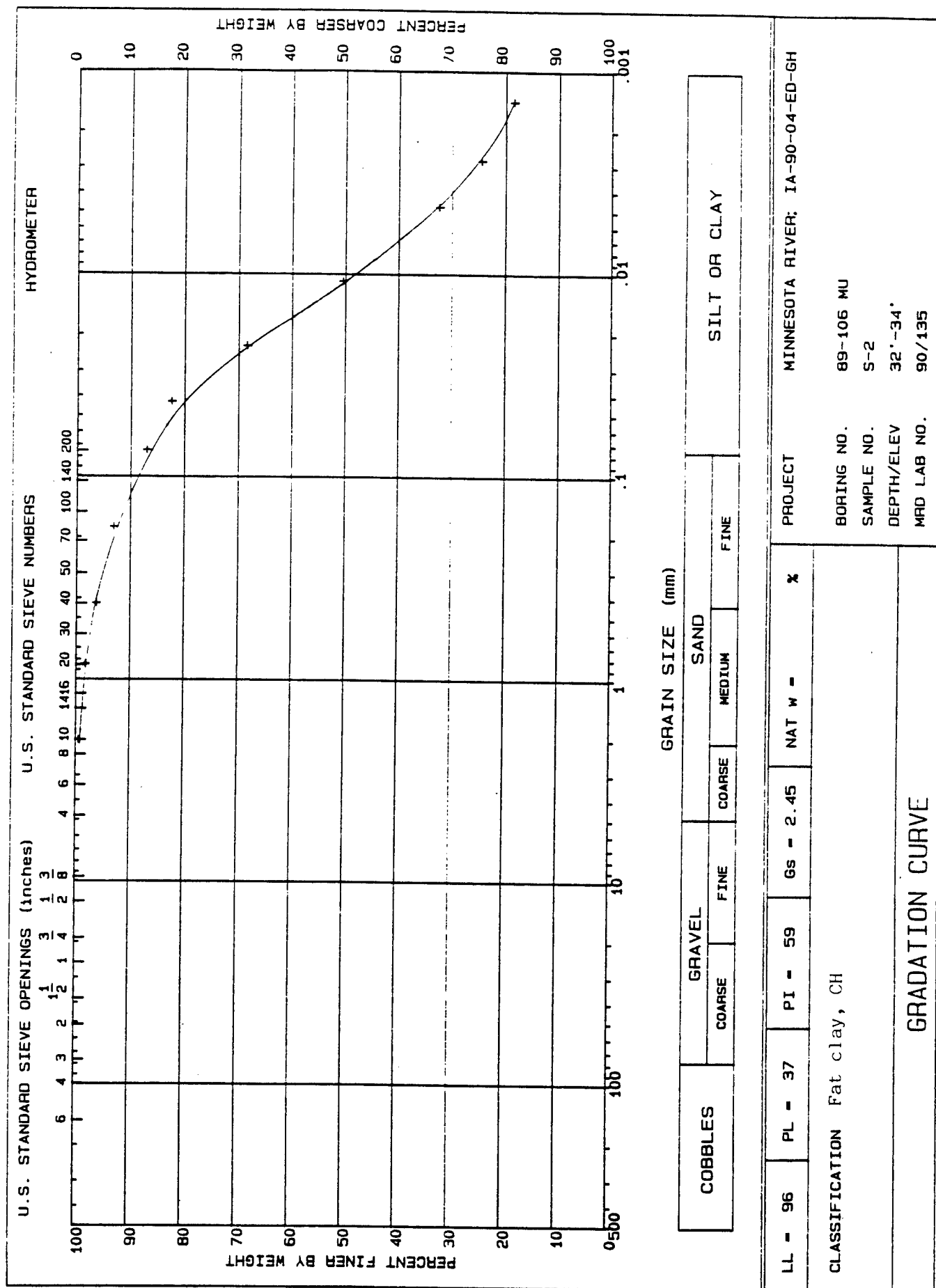
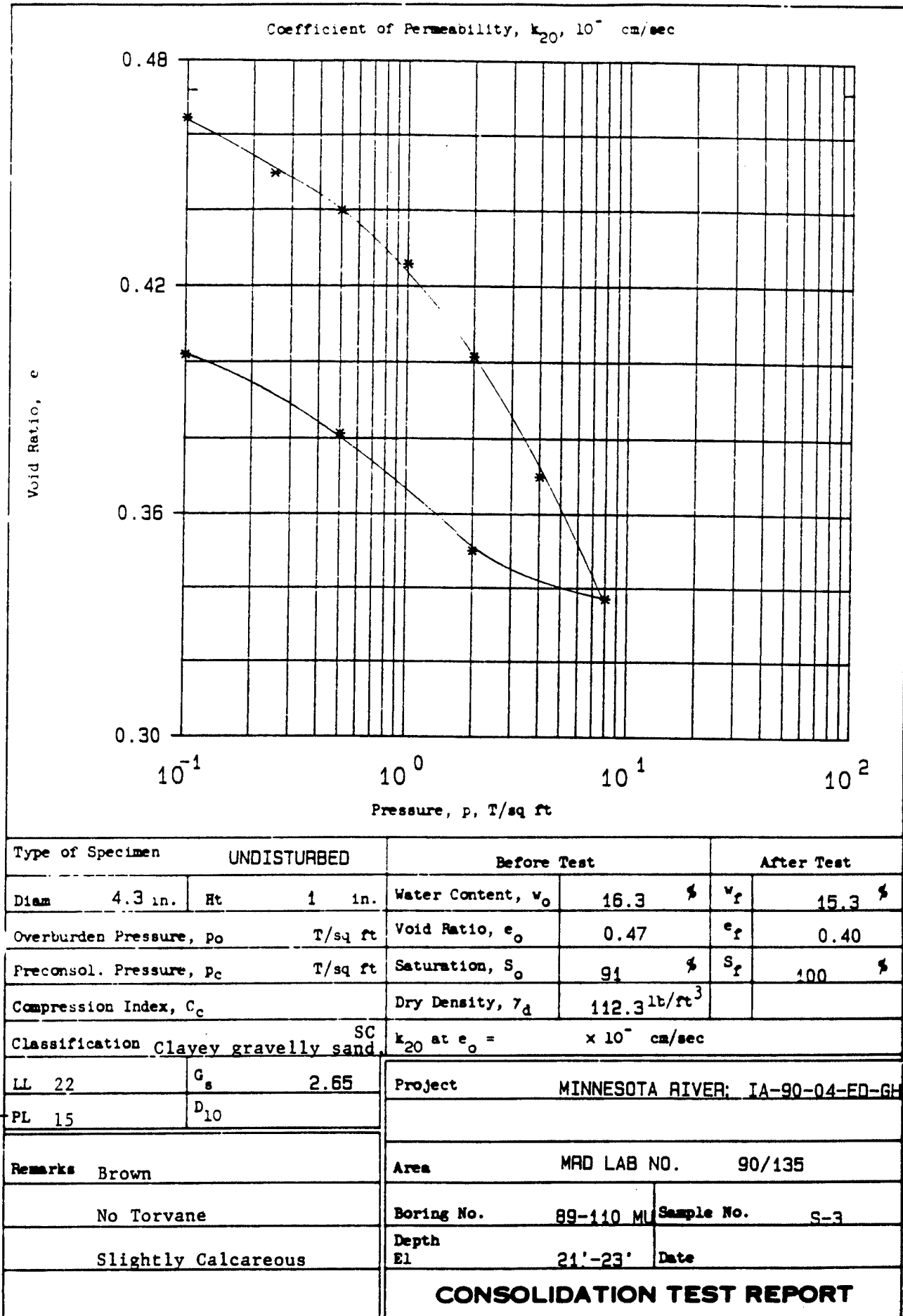
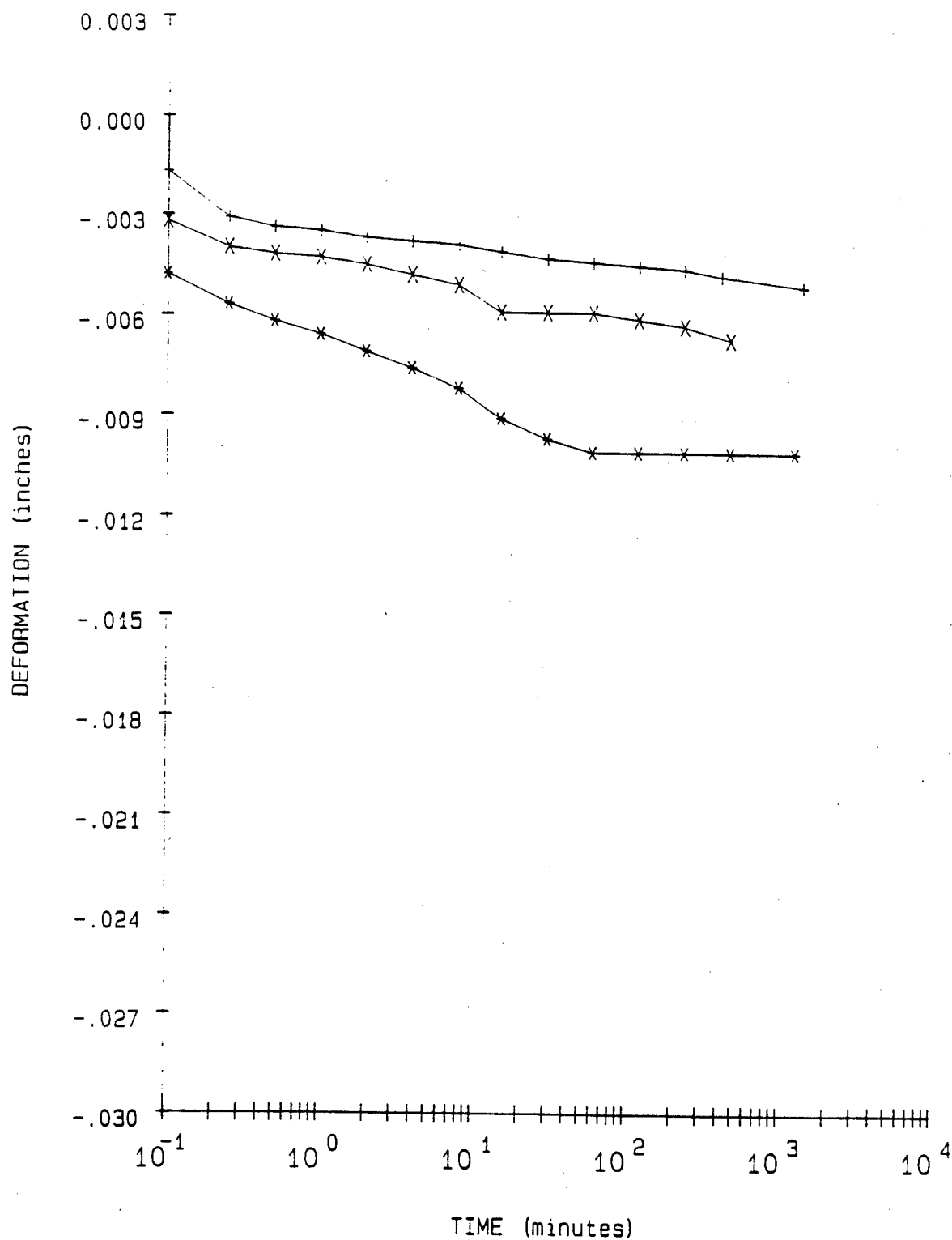


Figure C-335

due to lack of material no. 100 run

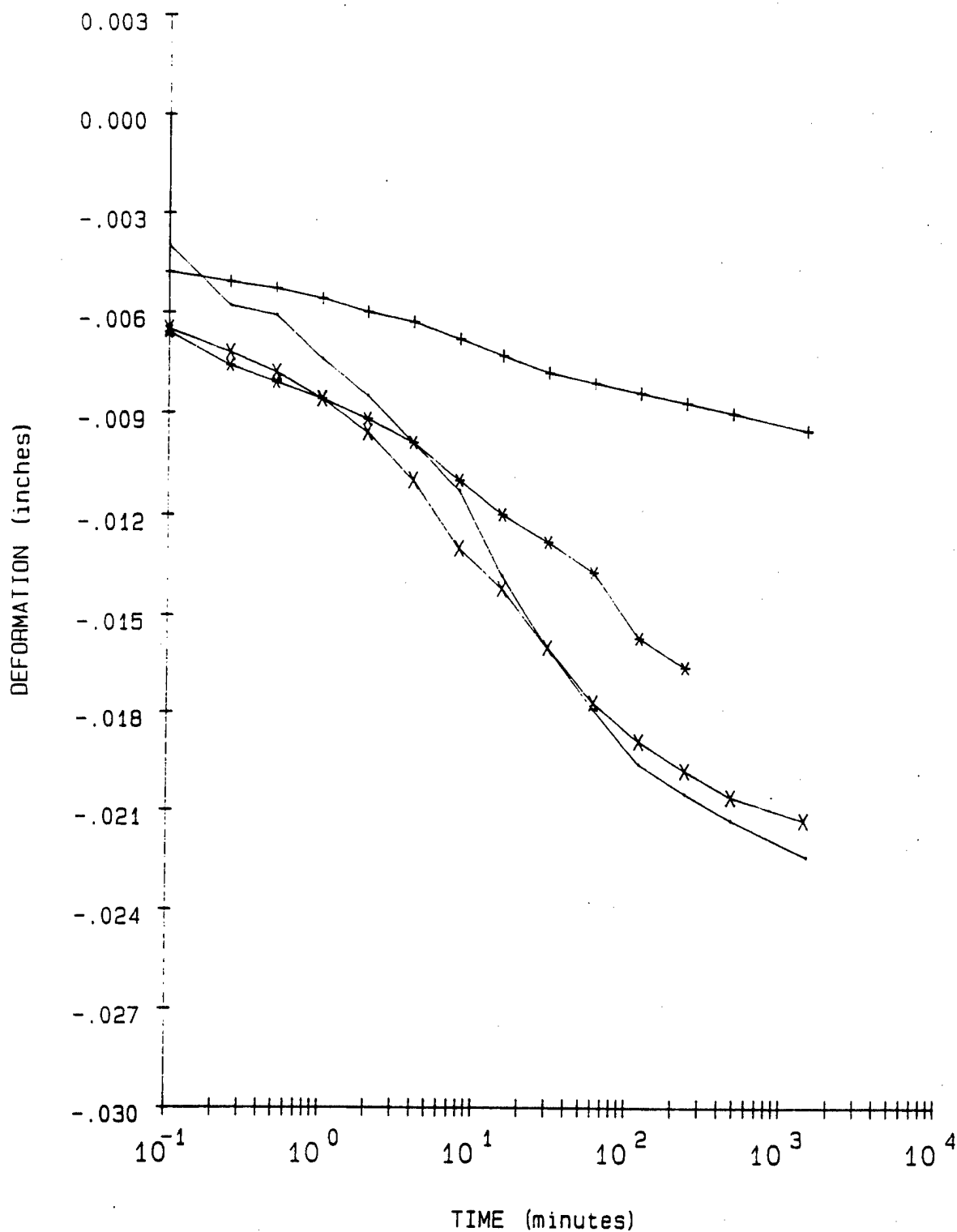




LEGEND  
 + = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT MINNESOTA RIVER; IA-90-04-ED-GH  
 BORING NO. 89-110 MU  
 SAMPLE NO. S-3  
 DEPTH/ELEV 21'-23'  
 MRD LAB NO. 90/135

FIGURE 10  
 Figure C-337



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-110 MU

SAMPLE NO.

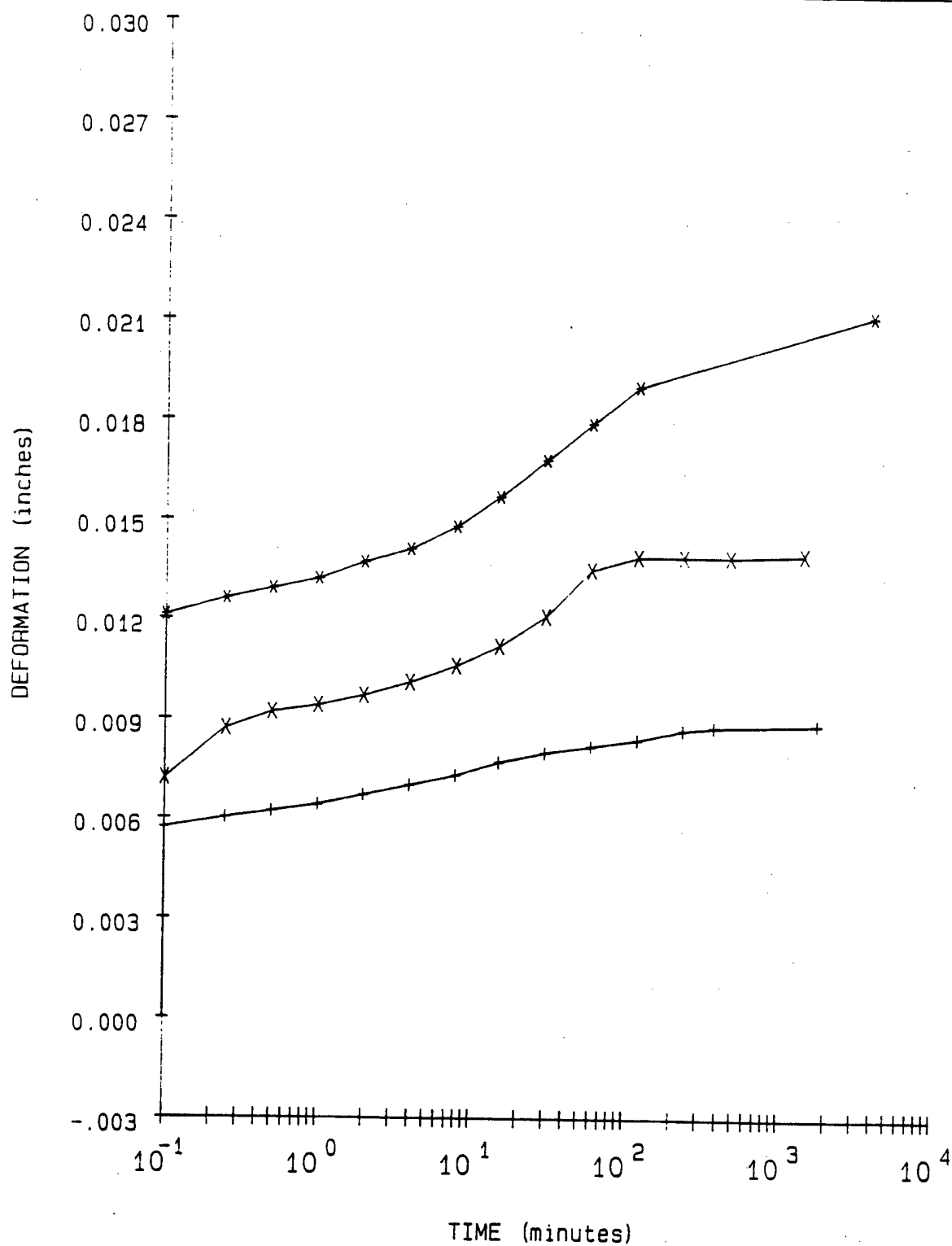
S-3

DEPTH/ELEV

21'-23'

MRD LAB NO.

90/135



LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-110 MU

SAMPLE NO.

S-3

DEPTH/ELEV

21'-23'

MRD LAB NO.

90/135

FIGURE 12

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-110 MU

Sample No. S-3

Depth/Elev 21'-23'

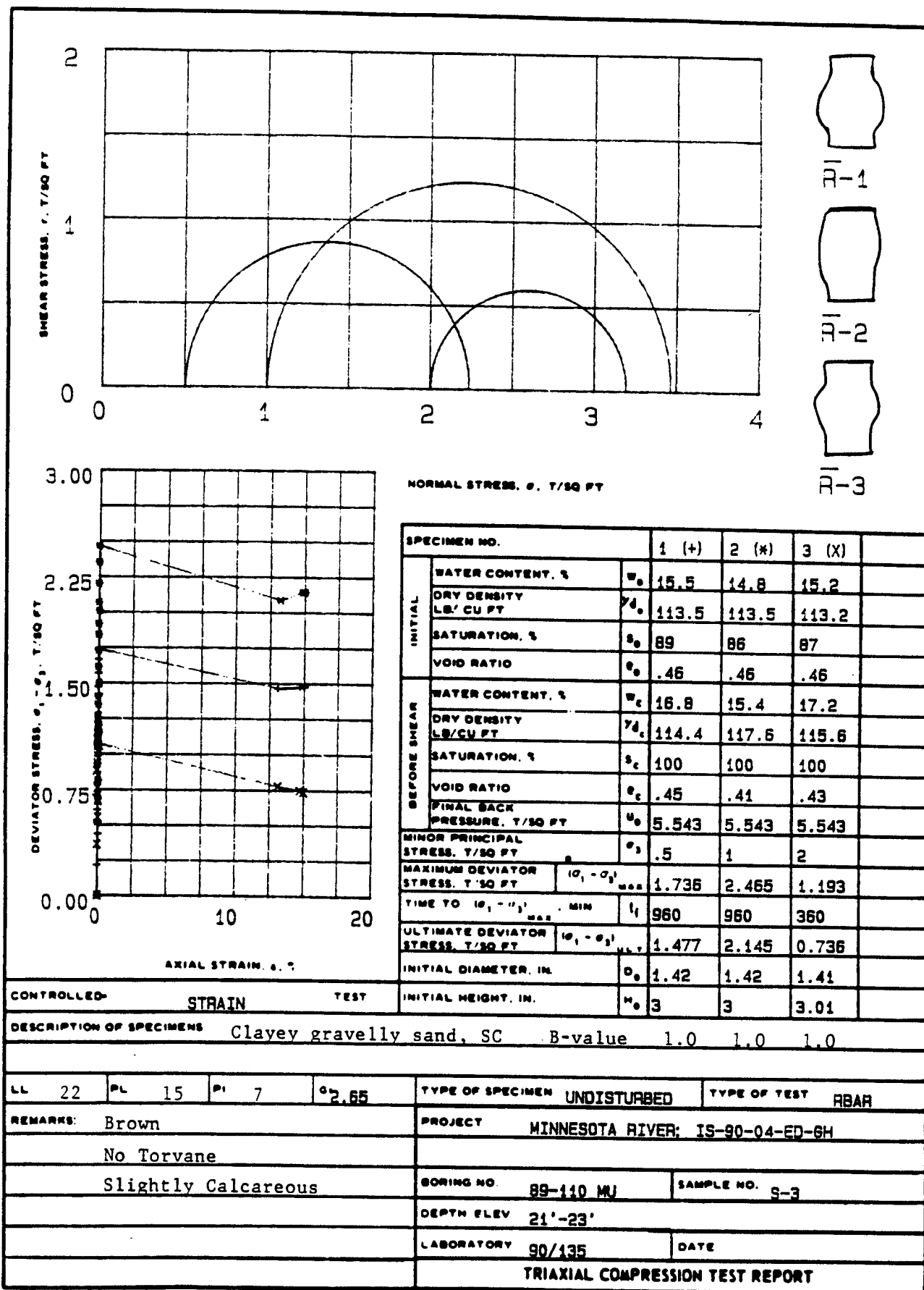
MRD Lab No. 90/135

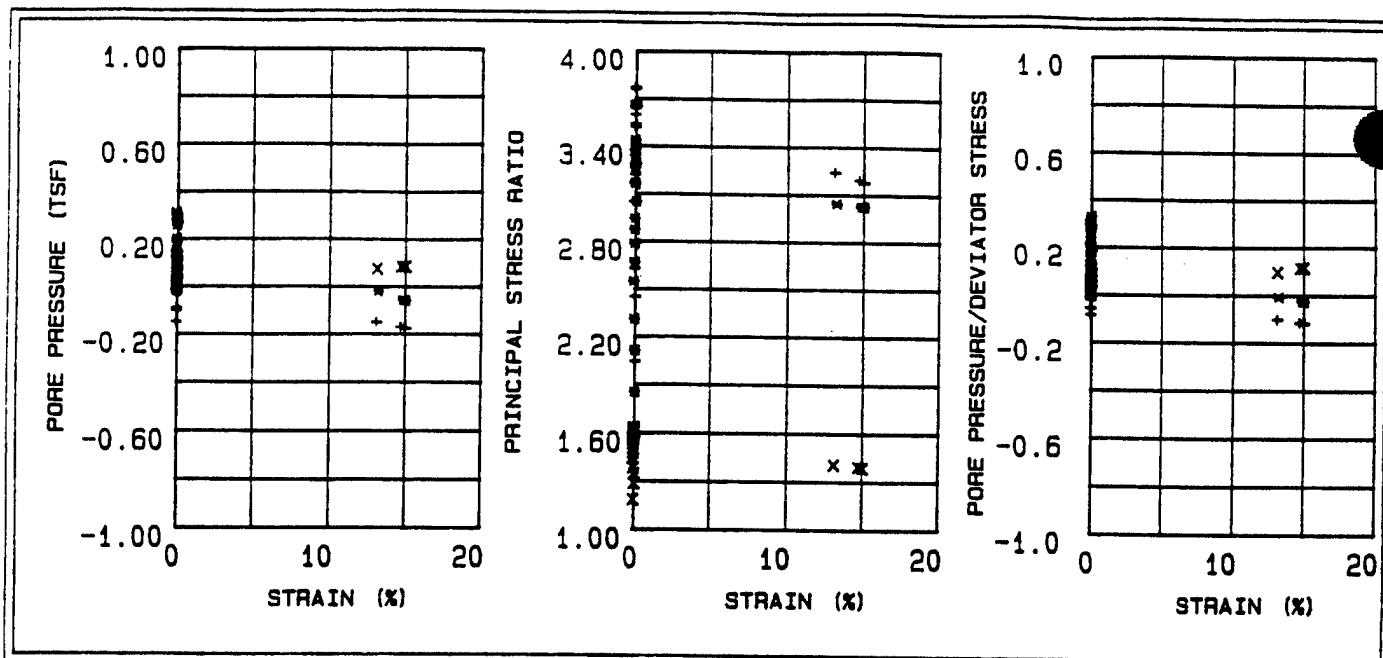
Gs = 2.65  
eo = 0.472  
0.42eo = 0.198

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
16.3	425.5	112.3	0.472		91.2
15.3	425.5	112.9	0.464	0.10	87.3
15.3	425.5	114.1	0.450	0.25	90.2
15.3	425.5	114.9	0.440	0.50	92.2
15.3	425.5	116.0	0.426	1.00	95.2
15.3	425.5	118.0	0.401	2.00	100.0
15.3	425.5	120.7	0.370	4.00	100.0
15.3	425.5	123.7	0.337	8.00	100.0
15.3	425.5	122.5	0.350	2.00	100.0
15.3	425.5	119.7	0.381	0.50	100.0
15.3	425.5	118.0	0.402	0.10	100.0

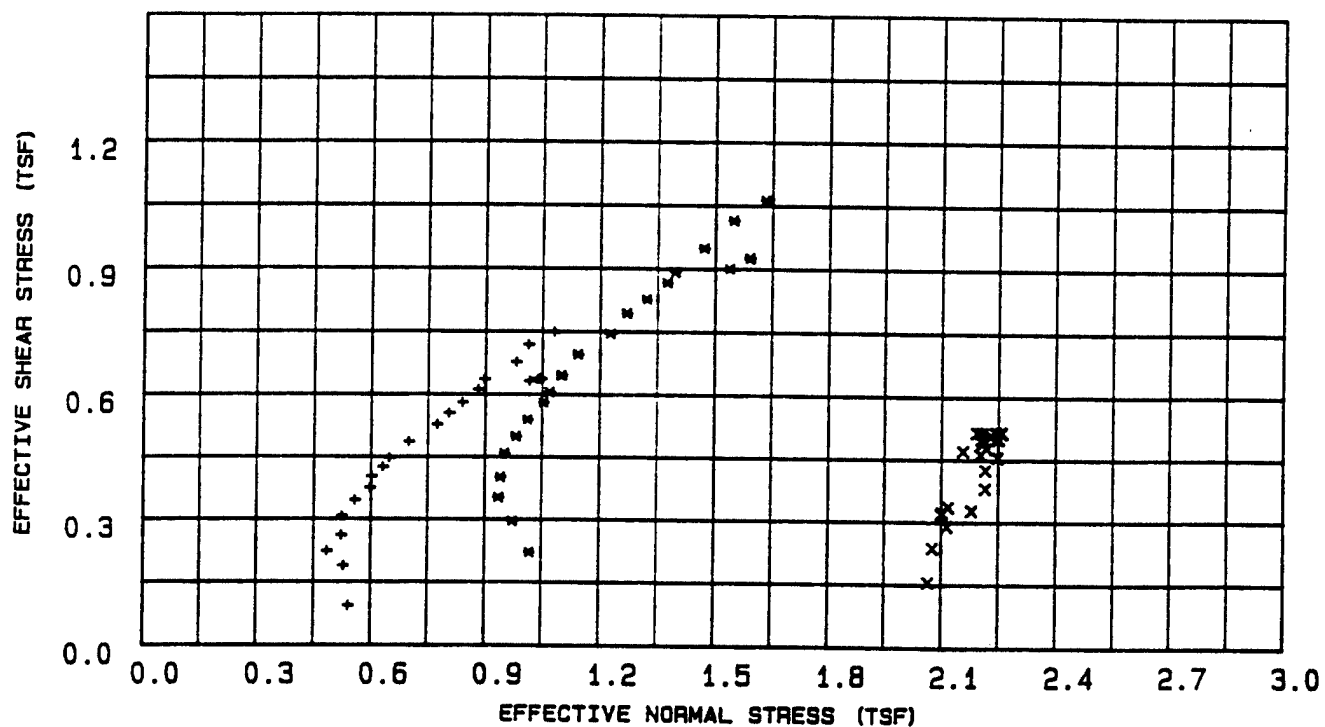
Axial Strain (%)	Void Ratio
1	0.457
2	0.442
3	0.428
4	0.413
5	0.398
6	0.384
7	0.369
8	0.354
9	0.339
10	0.325
11	0.310
12	0.295







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

MINNESOTA RIVER; IS-90-04-ED-6H

BORING NO.

89-110 MU

SAMPLE NO.

S-3

DEPTH/ELEV

21'-23'

MRD LAB NO.

90/135

FIGURE 14  
 Figure C-342

Table 5 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IS-90-04-ED-GH  
 Boring Number : 89-110 MU  
 Sample Number : S-3  
 Depth : 21'-23'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	-0.05	0.216	0.013	1.444	0.060	0.541	0.093
30	0.00	0.436	0.081	2.042	0.186	0.527	0.188
45	0.00	0.516	0.144	2.449	0.279	0.484	0.223
60	-0.05	0.605	0.128	2.626	0.212	0.522	0.261
90	-0.10	0.712	0.152	3.047	0.215	0.524	0.307
120	-0.05	0.799	0.140	3.218	0.175	0.558	0.345
150	-0.05	0.870	0.118	3.279	0.136	0.597	0.375
180	-0.05	0.932	0.130	3.518	0.140	0.601	0.402
210	-0.05	0.985	0.112	3.537	0.114	0.632	0.425
240	0.02	1.036	0.109	3.648	0.105	0.648	0.447
270	-0.05	1.126	0.080	3.681	0.071	0.699	0.486
300	-0.05	1.223	0.029	3.596	0.024	0.774	0.528
420	-0.05	1.285	0.013	3.638	0.010	0.805	0.555
480	-0.05	1.347	-0.007	3.654	-0.005	0.840	0.581
540	0.00	1.416	-0.030	3.673	-0.021	0.881	0.611
600	-0.05	1.471	-0.033	3.759	-0.022	0.897	0.635
720	-0.05	1.568	-0.092	3.650	-0.058	0.980	0.677
840	-0.05	1.665	-0.101	3.769	-0.060	1.013	0.719
960	-0.05	1.736	-0.151	3.665	-0.087	1.081	0.749
1080	13.09	1.463	-0.153	3.239	-0.104	1.015	0.631
1200	14.69	1.473	-0.173	3.191	-0.117	1.038	0.636
1223	15.00	1.477	-0.179	3.176	-0.121	1.045	0.637

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IS-90-04-ED-GH  
 Boring Number : 89-110 MU  
 Sample Number : S-3  
 Depth : 21'-23'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	-0.05	0.513	0.109	1.576	0.214	1.018	0.221
30	0.00	0.683	0.197	1.850	0.290	0.972	0.295
45	0.00	0.815	0.266	2.111	0.327	0.936	0.352
60	-0.05	0.930	0.289	2.308	0.311	0.941	0.401
90	-0.10	1.063	0.312	2.546	0.294	0.951	0.459
120	-0.05	1.157	0.305	2.665	0.264	0.981	0.499
150	-0.05	1.252	0.298	2.783	0.238	1.012	0.540
180	-0.05	1.347	0.280	2.871	0.209	1.053	0.581
210	-0.05	1.404	0.277	2.941	0.198	1.070	0.606
240	0.02	1.497	0.270	3.049	0.181	1.101	0.646
300	-0.05	1.612	0.256	3.166	0.159	1.143	0.696
360	-0.05	1.726	0.201	3.160	0.117	1.226	0.745
420	-0.05	1.839	0.187	3.262	0.102	1.268	0.791
480	-0.05	1.915	0.153	3.262	0.081	1.321	0.821
5	0.00	2.009	0.122	3.287	0.061	1.375	0.867
600	-0.05	2.067	0.116	3.339	0.057	1.396	0.892
720	-0.05	2.200	0.074	3.375	0.034	1.471	0.949
840	-0.05	2.351	0.035	3.437	0.015	1.547	1.015
960	-0.05	2.465	-0.021	3.414	-0.008	1.631	1.064
1080	13.21	2.086	-0.021	3.043	-0.010	1.537	0.900
1200	14.83	2.144	-0.058	3.026	-0.027	1.589	0.925
1212	15.00	2.145	-0.060	3.023	-0.028	1.591	0.926

Table 6 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IS-90-04-ED-GH  
 Boring Number : 89-110 MU  
 Sample Number : S-3  
 Depth : 21'-23'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	-0.05	0.359	0.024	1.182	0.068	2.065	0.155
30	0.00	0.549	0.059	1.283	0.107	2.077	0.237
45	0.00	0.671	0.051	1.344	0.077	2.115	0.289
60	-0.05	0.758	0.008	1.381	0.010	2.180	0.327
90	-0.10	0.881	0.003	1.441	0.004	2.215	0.380
120	-0.05	0.984	0.029	1.499	0.030	2.215	0.425
150	-0.05	1.054	0.014	1.530	0.013	2.247	0.455
180	-0.05	1.106	0.056	1.569	0.051	2.218	0.477
210	-0.05	1.140	0.072	1.592	0.064	2.210	0.492
240	0.02	1.174	0.062	1.606	0.053	2.229	0.507
300	-0.05	1.158	0.038	1.590	0.033	2.249	0.500
360	-0.05	1.193	0.053	1.612	0.045	2.242	0.515
420	-0.05	1.193	0.038	1.608	0.032	2.257	0.515
480	-0.05	1.193	0.102	1.629	0.086	2.193	0.515
540	0.00	1.192	0.089	1.624	0.075	2.206	0.514
600	-0.05	1.193	0.102	1.629	0.086	2.193	0.515
720	-0.05	1.158	0.081	1.603	0.071	2.206	0.500
840	-0.05	1.088	0.113	1.577	0.104	2.156	0.470
960	-0.05	1.071	0.063	1.553	0.060	2.202	0.462
1080	13.12	0.777	0.074	1.404	0.095	2.118	0.335
1200	14.72	0.746	0.084	1.390	0.113	2.101	0.322
1221	15.00	0.736	0.084	1.384	0.115	2.098	0.318

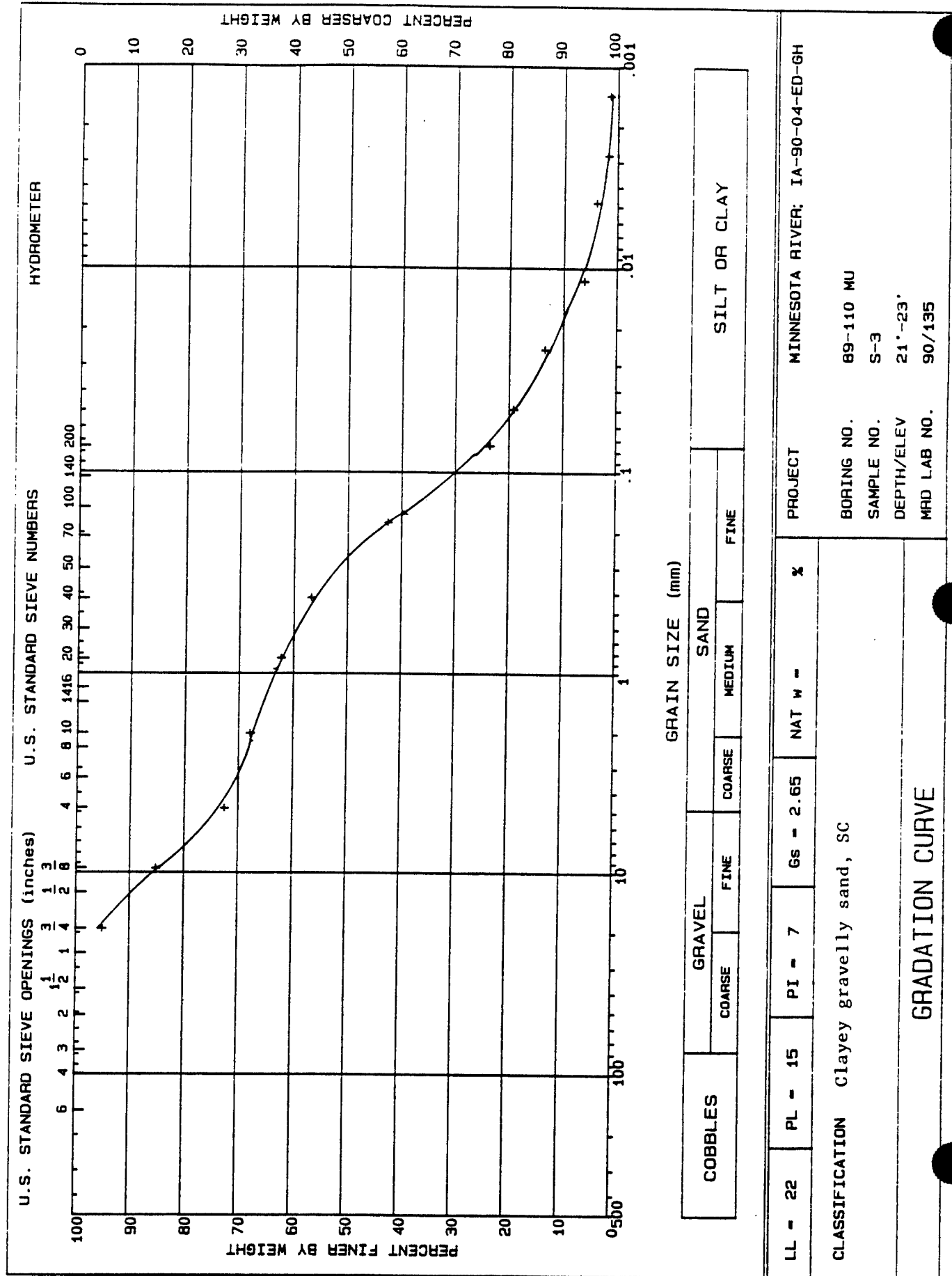
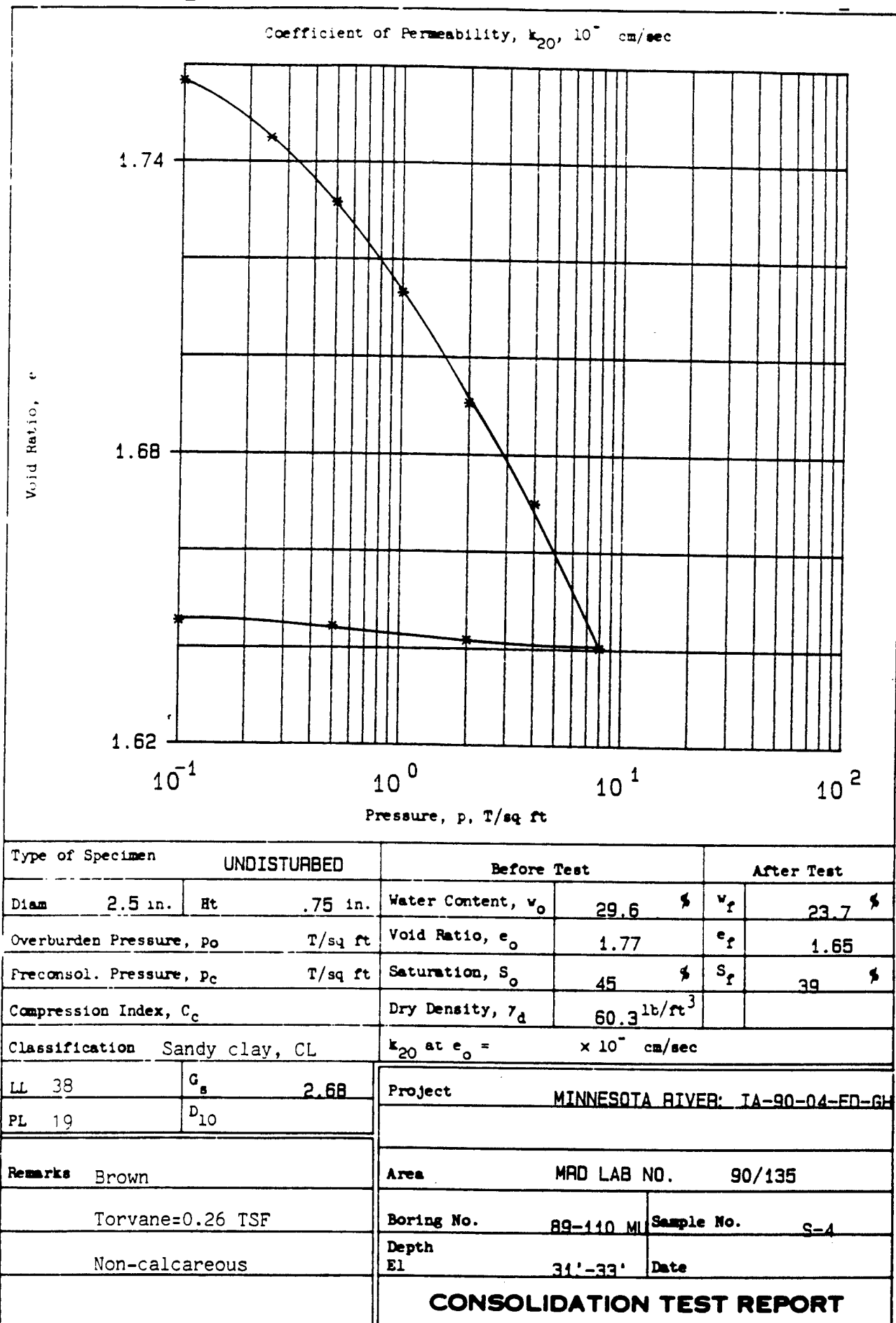
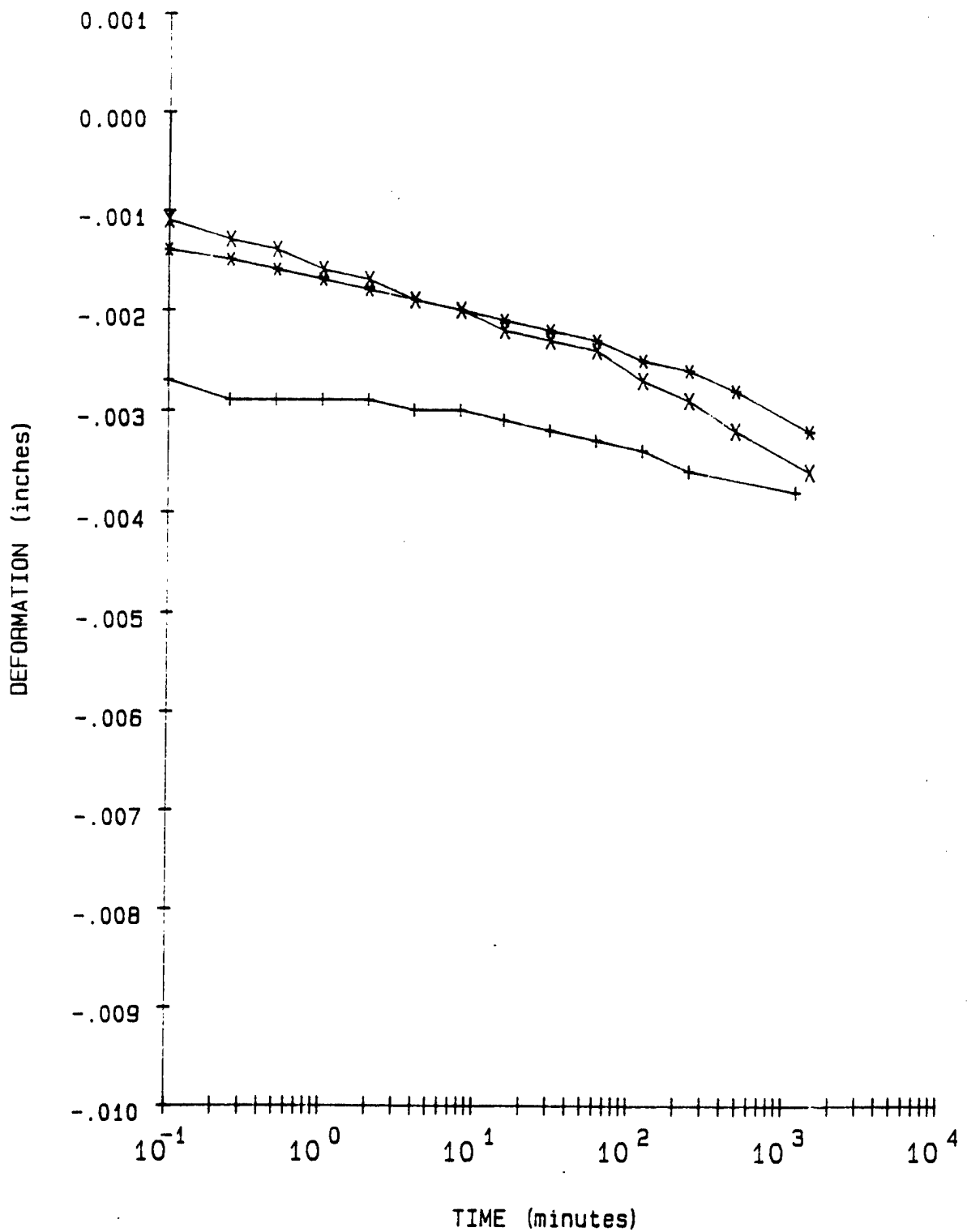


FIGURE 15





LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-110 MU

SAMPLE NO.

S-4

DEPTH/ELEV

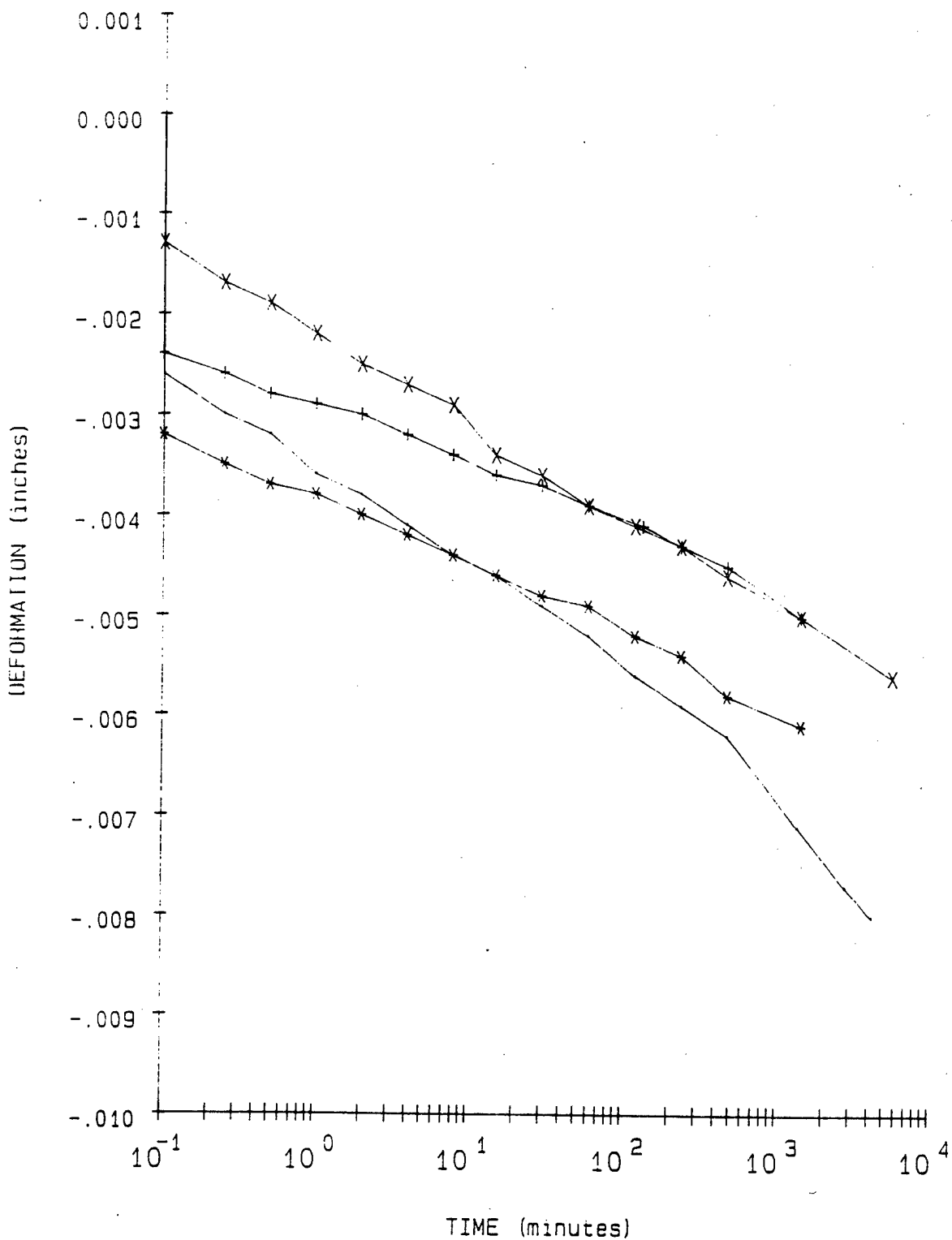
31'-33'

MRD LAB NO.

90/135

FIGURE 34





LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-110 MU

SAMPLE NO.

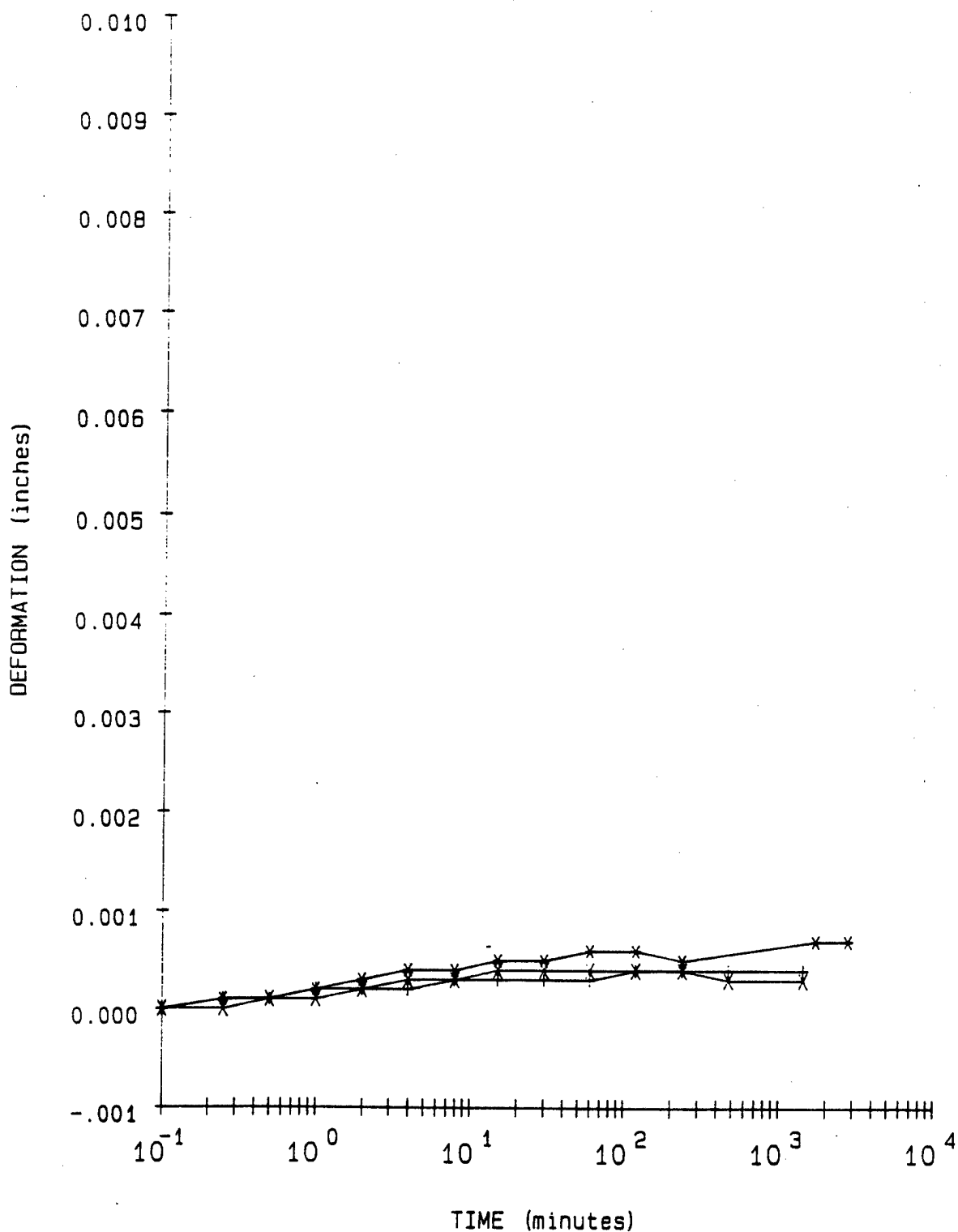
S-4

DEPTH/ELEV

31'-33'

MAD LAB NO.

90/135



LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT

MINNESOTA RIVER; IA-90-04-ED-6H

BORING NO.

89-110 MU

SAMPLE NO.

S-4

DEPTH/ELEV

31'-33'

MRO LAB NO.

90/135

FIGURE 36

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-110 MU

Sample No. S-4

Depth/Elev 31'-33'

MRD Lab No. 90/135

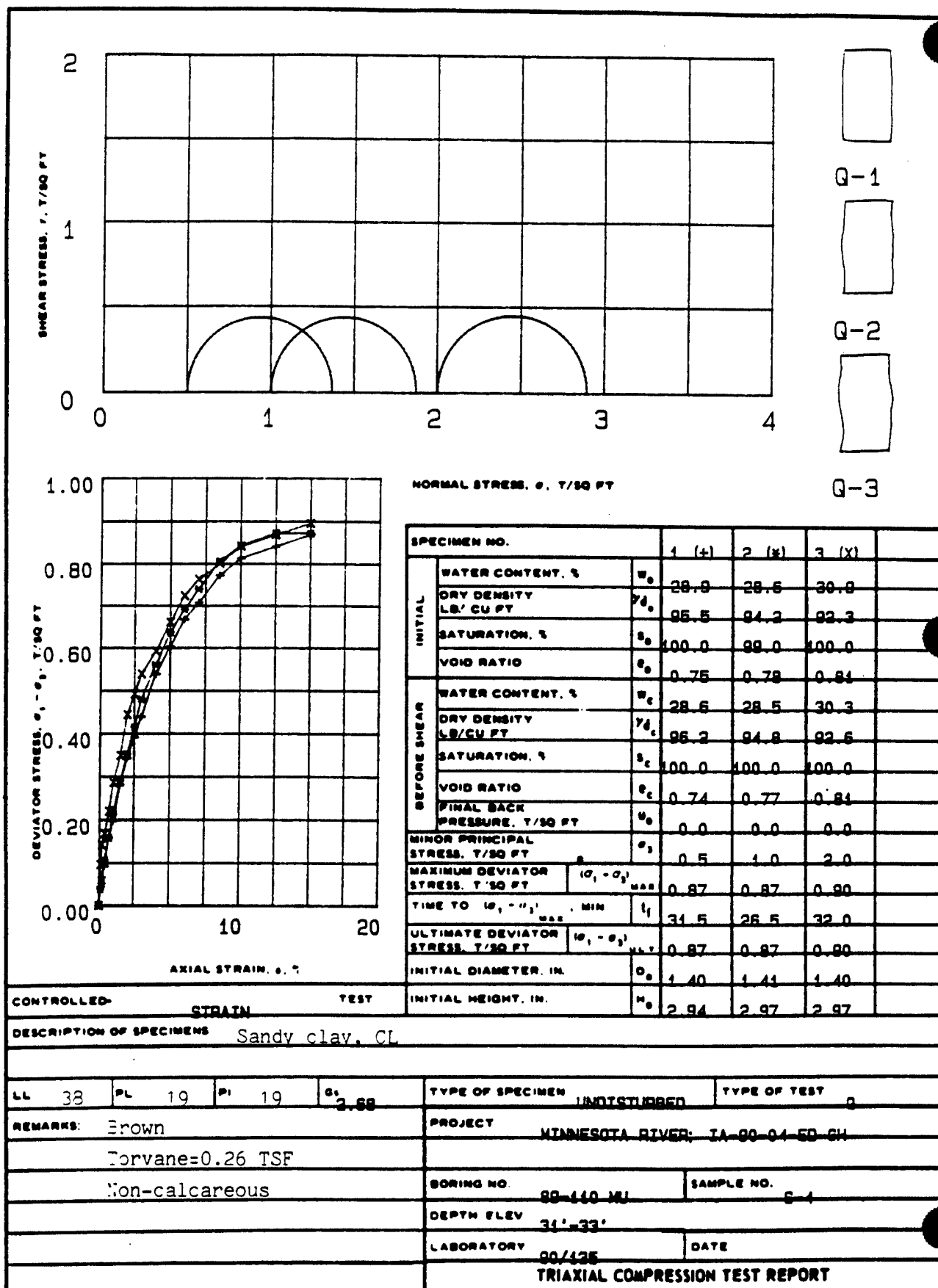
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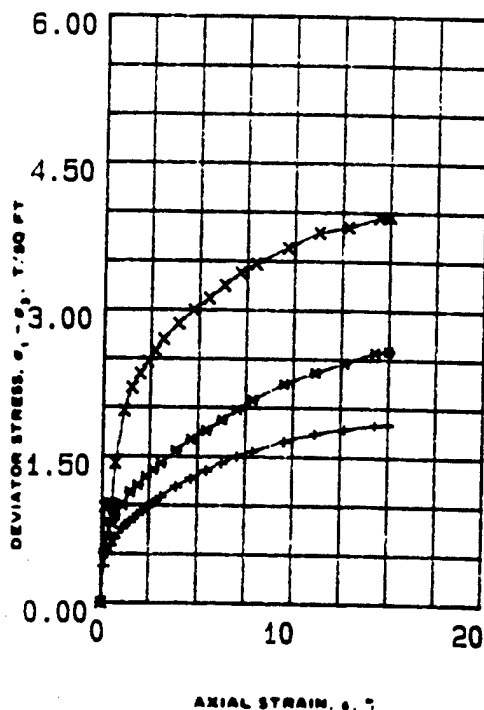
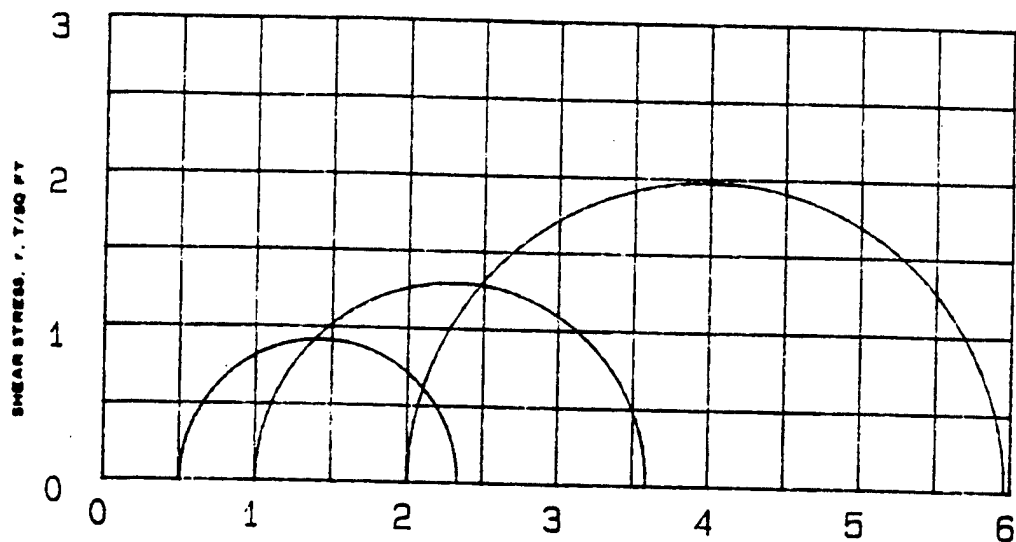
eo = 1.773

0.42eo = 0.745

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
29.6	58.3	60.3	1.773		44.8
23.7	58.3	60.7	1.757	0.10	36.2
23.7	58.3	60.9	1.745	0.25	36.5
23.7	58.3	61.2	1.732	0.50	36.7
23.7	58.3	61.6	1.713	1.00	37.1
23.7	58.3	62.2	1.691	2.00	37.6
23.7	58.3	62.6	1.670	4.00	38.1
23.7	58.3	63.3	1.640	8.00	38.8
23.7	58.3	63.3	1.642	2.00	38.8
23.7	58.3	63.2	1.644	0.50	38.7
23.7	58.3	63.2	1.645	0.10	38.7

Axial Strain (%)	Void Ratio
1	1.746
2	1.718
3	1.690
4	1.662
5	1.635
6	1.607
7	1.579





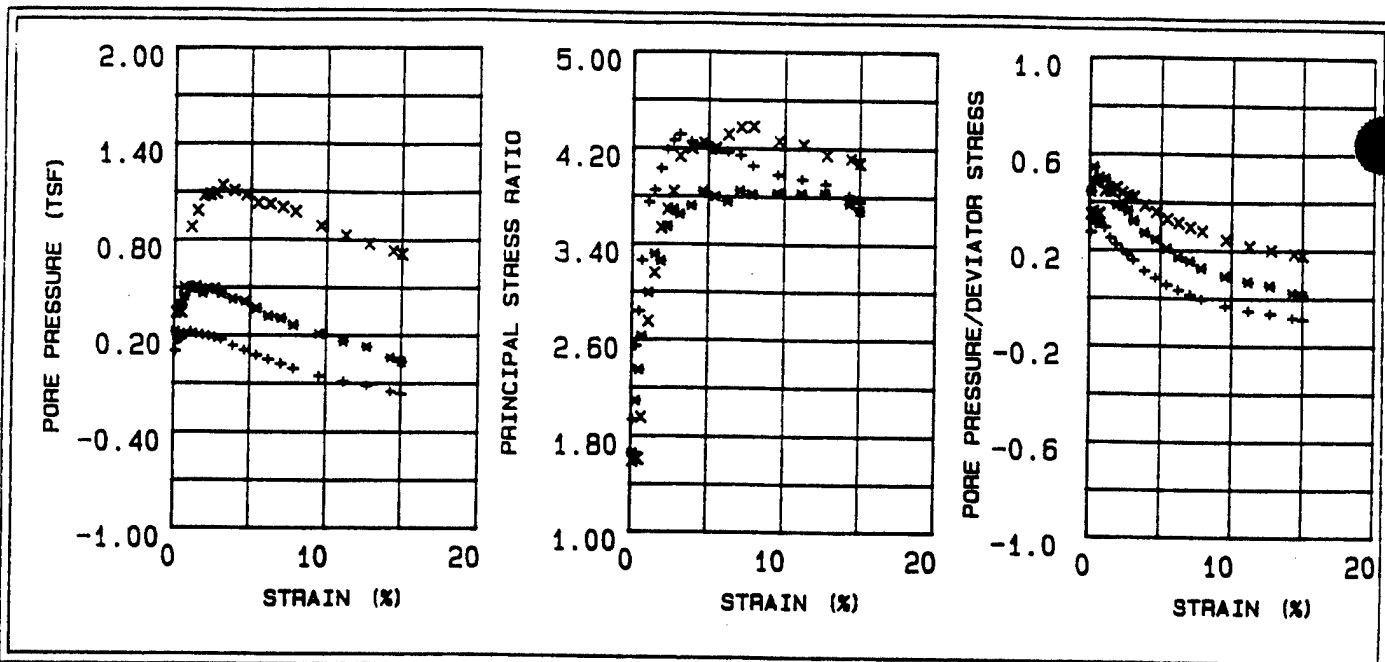
NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (*)	3 (X)
INITIAL	WATER CONTENT, %	$w_o$ 28	27.7	28.3
	DRY DENSITY LB./CU FT	$\gamma_d$ 96	96.1	95.3
	SATURATION, %	$s_o$ 100	100	100
	VOID RATIO	$e_o$ .74	.74	.76
BEFORE SHEAR	WATER CONTENT, %	$w_c$ 25.9	24.6	24.5
	DRY DENSITY LB./CU FT	$\gamma_d$ 99.2	101.2	101.3
	SATURATION, %	$s_c$ 100	100	100
	VOID RATIO	$e_c$ .69	.65	.65
	FINAL BACK PRESSURE, T/50 FT	$u_o$ 5.543	5.543	5.543
	MINOR PRINCIPAL STRESS, T/50 FT	$\sigma_3$ .5	1	2
MAXIMUM DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{max}$ 1.835	2.591	3.960
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		$t_f$ 1130	1131	1122
ULTIMATE DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{ult}$ 1.835	2.591	3.960
INITIAL DIAMETER, IN.		$d_o$ 1.41	1.39	1.4
INITIAL HEIGHT, IN.		$h_o$ 2.97	2.99	2.98

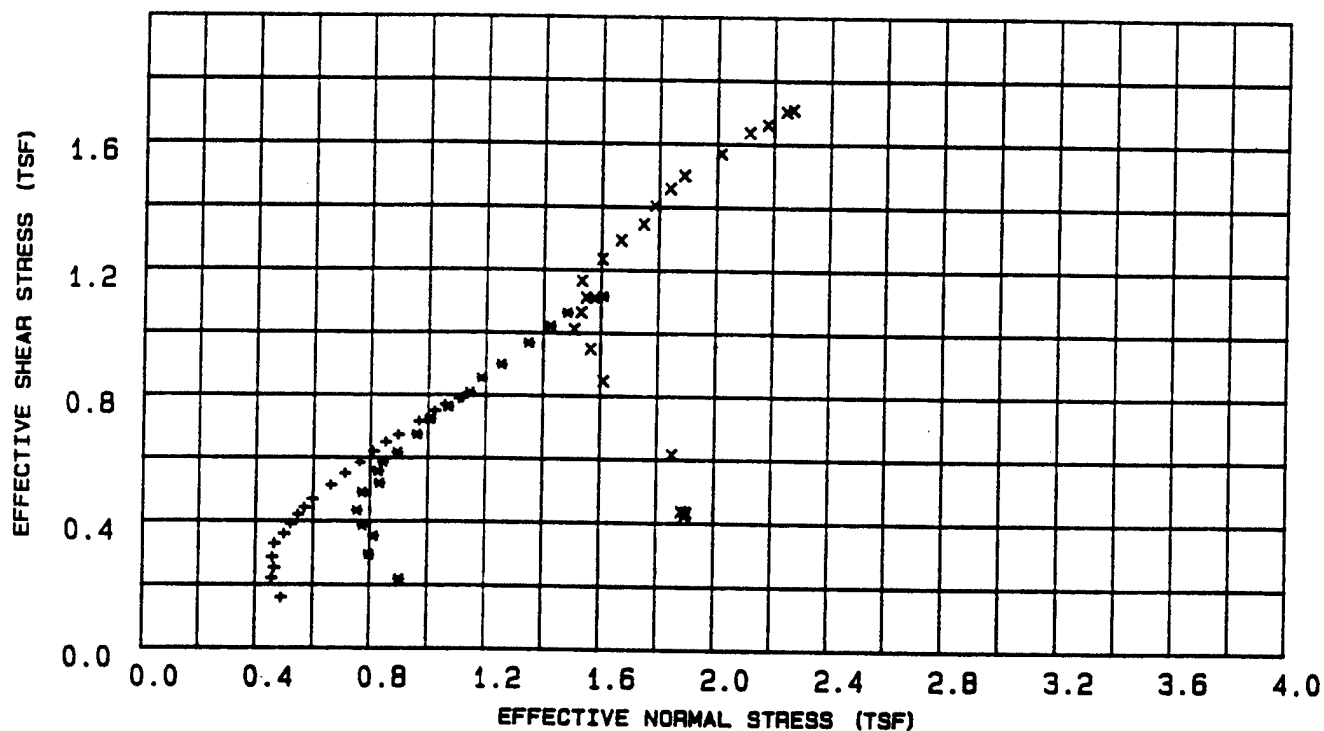
CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS Sandy clay, CL B-value 1.0 1.0 1.0

LL 38	PL 19	PI 19	$\sigma'_{2.68}$	TYPE OF SPECIMEN UNDISTURBED	TYPE OF TEST RBAR
REMARKS: Brown				PROJECT MINNESOTA RIVER: IA-90-04-ED-6H	
Torvane=0.26 TSF					
Non-calcareous				BORING NO. 89-110 MU	SAMPLE NO. S-4
				DEPTH FLEV 31'-33'	
				LABORATORY 90/135	DATE
TRIAXIAL COMPRESSION TEST REPORT					



EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO.

89-110 MU

SAMPLE NO.

S-4

DEPTH/ELEV

31'-33'

MRO LAB NO.

90/135

Table 13 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-110 MU  
 Sample Number : S-4  
 Depth : 31'-33'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.14	0.372	0.102	1.933	0.275	0.490	0.160
30	0.31	0.510	0.170	2.547	0.334	0.456	0.220
45	0.51	0.587	0.180	2.835	0.308	0.465	0.253
60	0.70	0.663	0.207	3.260	0.313	0.457	0.286
90	1.11	0.761	0.223	3.748	0.294	0.465	0.328
120	1.49	0.833	0.208	3.850	0.250	0.498	0.359
150	1.90	0.903	0.202	4.029	0.224	0.522	0.390
180	2.32	0.973	0.195	4.187	0.200	0.546	0.420
210	2.70	1.026	0.185	4.262	0.181	0.569	0.443
240	3.11	1.086	0.172	4.314	0.159	0.597	0.469
300	3.88	1.189	0.134	4.254	0.114	0.660	0.513
360	4.65	1.274	0.106	4.232	0.084	0.709	0.550
420	5.45	1.356	0.074	4.185	0.055	0.762	0.585
480	6.24	1.436	0.047	4.170	0.033	0.809	0.620
540	7.07	1.506	0.020	4.141	0.014	0.853	0.650
600	7.89	1.558	-0.010	4.055	-0.006	0.896	0.673
720	9.55	1.658	-0.056	3.982	-0.033	0.967	0.716
840	11.16	1.739	-0.091	3.944	-0.052	1.021	0.750
960	12.71	1.786	-0.115	3.904	-0.064	1.057	0.771
1080	14.30	1.829	-0.151	3.810	-0.082	1.104	0.789
1129	15.00	1.835	-0.165	3.760	-0.089	1.119	0.792

Table 14 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-110 MU  
 Sample Number : S-4  
 Depth : 31'-33'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.14	0.507	0.224	1.654	0.442	0.902	0.219
30	0.31	0.684	0.373	2.091	0.546	0.796	0.295
45	0.51	0.819	0.392	2.348	0.480	0.811	0.354
60	0.70	0.895	0.450	2.627	0.503	0.772	0.386
90	1.11	1.005	0.496	2.993	0.494	0.753	0.434
120	1.49	1.135	0.510	3.319	0.450	0.771	0.490
150	1.90	1.205	0.466	3.257	0.388	0.832	0.520
180	2.31	1.293	0.493	3.549	0.382	0.827	0.558
210	2.70	1.362	0.494	3.692	0.363	0.843	0.588
240	3.11	1.429	0.460	3.648	0.323	0.894	0.617
300	3.88	1.563	0.426	3.725	0.273	0.961	0.675
360	4.65	1.676	0.410	3.842	0.245	1.005	0.724
420	5.44	1.768	0.369	3.800	0.209	1.069	0.763
480	6.24	1.876	0.320	3.759	0.171	1.144	0.811
540	7.06	1.981	0.305	3.852	0.155	1.185	0.855
600	7.87	2.084	0.261	3.820	0.126	1.255	0.899
720	9.54	2.246	0.207	3.831	0.092	1.349	0.969
840	11.15	2.367	0.162	3.825	0.069	1.424	1.022
960	12.69	2.467	0.128	3.830	0.053	1.483	1.065
1080	14.28	2.577	0.060	3.743	0.024	1.578	1.112
1131	15.00	2.591	0.035	3.687	0.014	1.607	1.118



Table 15 - Triaxial  $\bar{R}$  Test Results

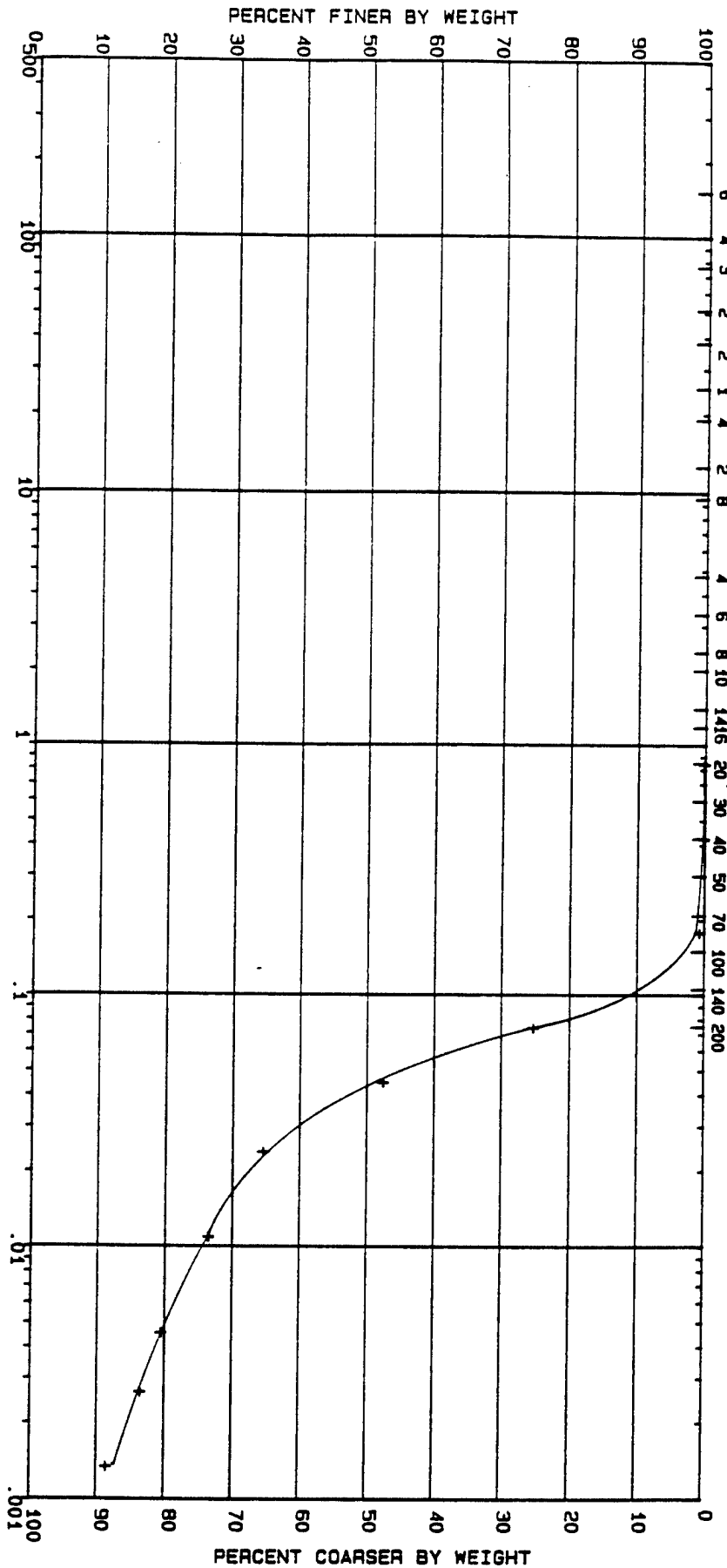
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-110 MU  
 Sample Number : S-4  
 Depth : 31'-33'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.14	0.978	0.342	1.589	0.350	1.900	0.422
30	0.32	1.010	0.363	1.617	0.360	1.887	0.436
45	0.51	1.006	0.345	1.608	0.343	1.904	0.434
60	0.70	1.428	0.501	1.953	0.351	1.853	0.616
90	1.12	1.966	0.878	2.752	0.447	1.609	0.848
120	1.51	2.201	0.981	3.159	0.446	1.564	0.950
150	1.92	2.345	1.075	3.536	0.459	1.506	1.012
180	2.33	2.471	1.082	3.690	0.438	1.530	1.066
210	2.72	2.579	1.091	3.838	0.424	1.547	1.113
240	3.14	2.702	1.137	4.131	0.421	1.532	1.166
300	3.91	2.861	1.106	4.201	0.387	1.602	1.235
360	4.69	3.001	1.075	4.245	0.359	1.668	1.295
420	5.49	3.120	1.026	4.204	0.330	1.746	1.346
480	6.29	3.253	1.020	4.319	0.314	1.785	1.404
5	7.12	3.381	0.999	4.377	0.296	1.838	1.459
600	7.95	3.475	0.973	4.382	0.280	1.887	1.500
720	9.62	3.637	0.885	4.261	0.244	2.015	1.570
840	11.25	3.792	0.826	4.231	0.218	2.113	1.637
960	12.80	3.850	0.776	4.145	0.202	2.177	1.662
1080	14.41	3.946	0.734	4.116	0.186	2.243	1.703
1121	15.00	3.960	0.713	4.078	0.180	2.267	1.709

U.S. STANDARD SIEVE OPENINGS (Inches)

U.S. STANDARD SIEVE NUMBERS

HYDROMETER



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LL - 38	PL - 19	PI - 19	Gs - 2.68	NAT w -	%
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CLASSIFICATION Sandy clay, CL.

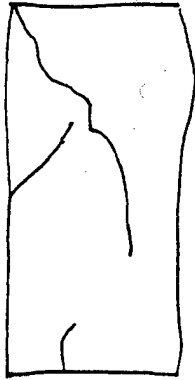
# GRADATION CURVE

PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
BORING NO.	89-110 MU
SAMPLE NO.	S-4
DEPTH/ELEV	31'-33'
MRD LAB NO.	90/135

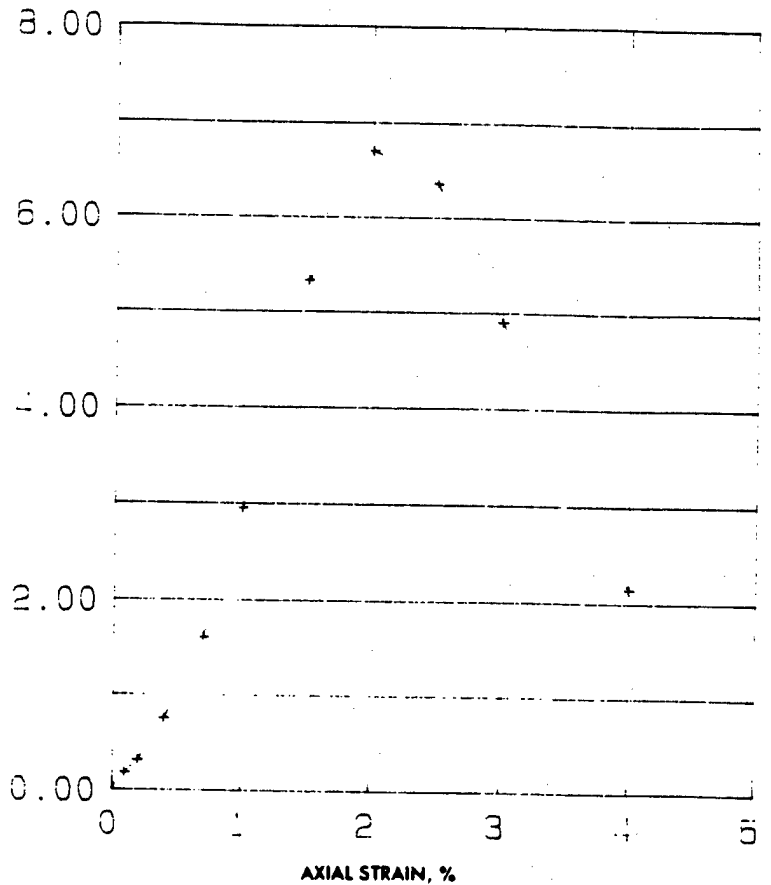
FIGURE 40

too brittle for 2 or 3 bar tests

# FAILURE SKETCHES



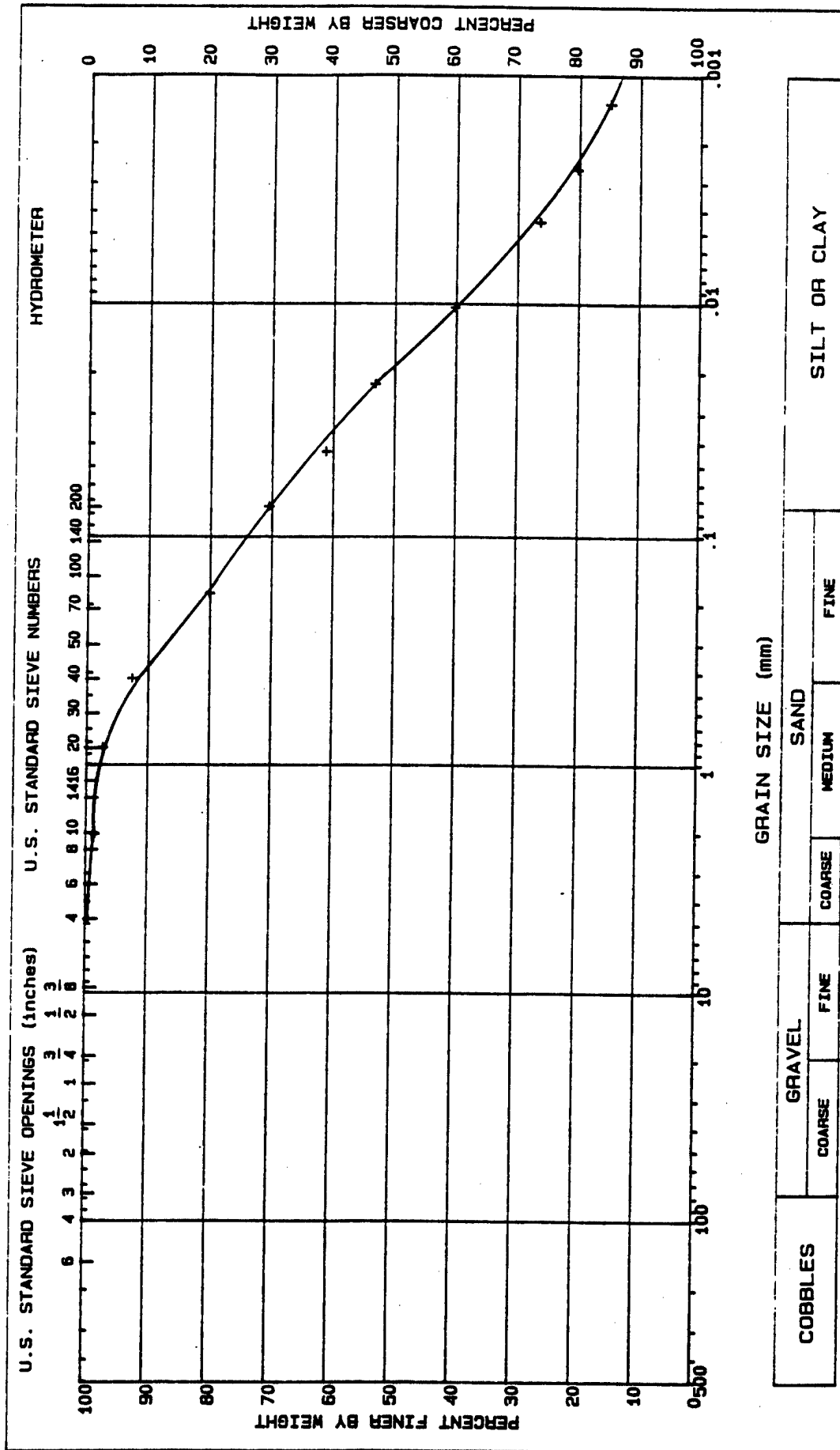
COMPRESSIVE STRESS, T/SQ FT



☐ CONTROLLED STRESS

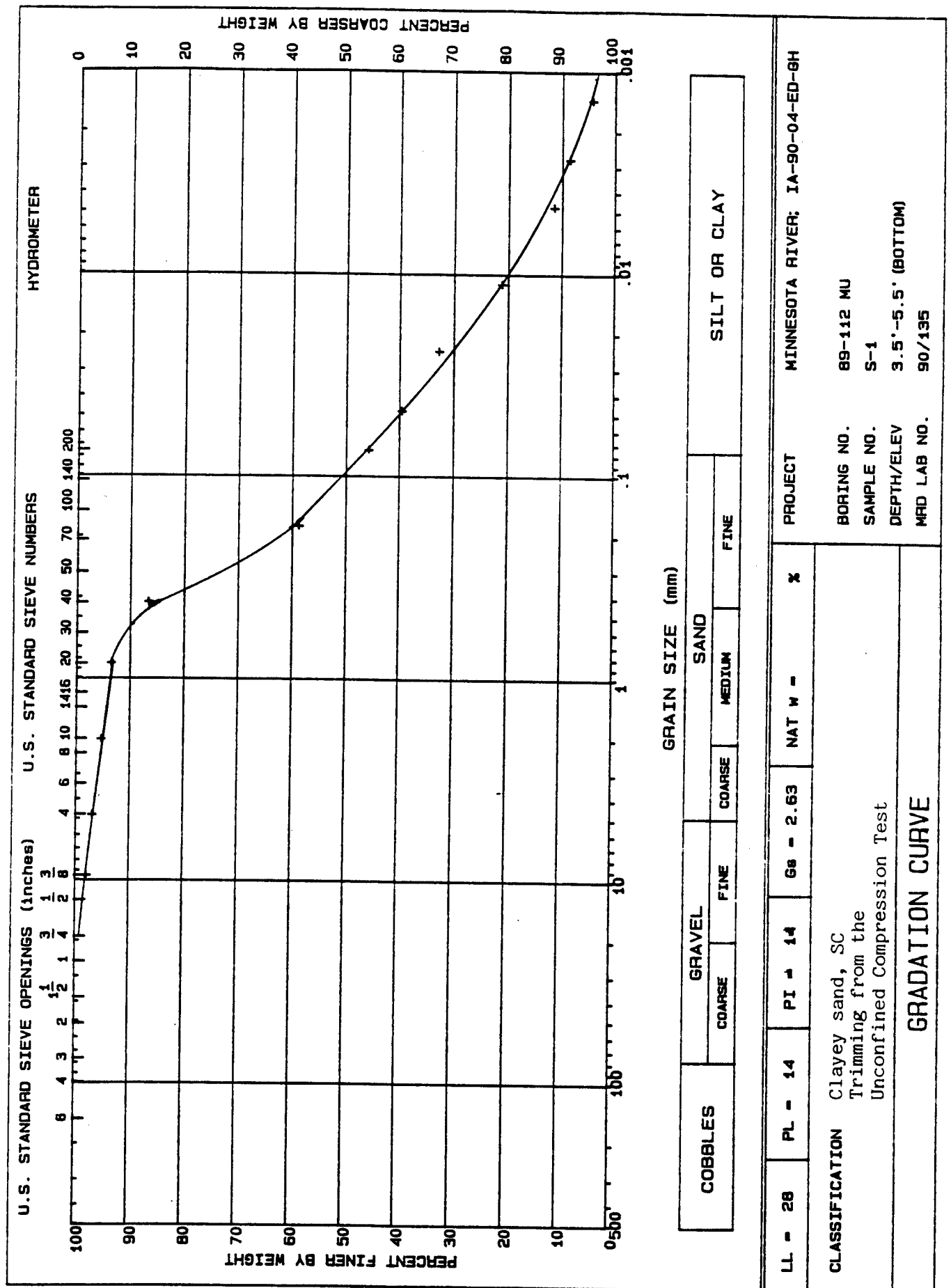
☒ CONTROLLED STRAIN

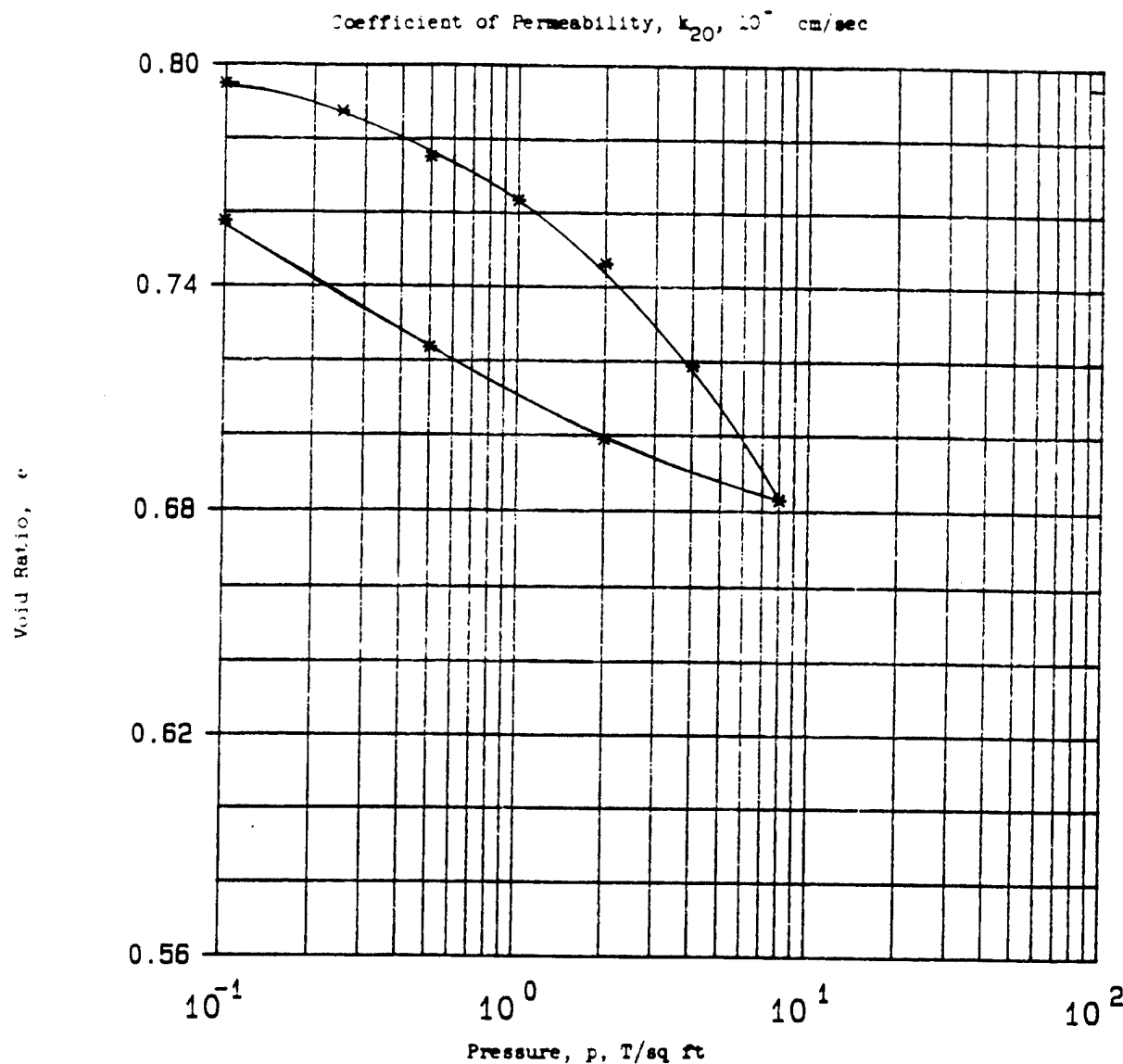
TEST NO.					
TYPE OF SPECIMEN		UNDISTURBED			
INITIAL	WATER CONTENT	w <sub>o</sub>	10.2 %	%	%
	VOID RATIO	e <sub>o</sub>	0.42		
	SATURATION	S <sub>o</sub>	63 %	%	%
	DRY DENSITY, LB/CU FT	γ <sub>d</sub>	115.2		
TIME TO FAILURE, MIN		t <sub>f</sub>	8.3		
UNCONFINED COMPRESSIVE STRENGTH, T/SQ FT		q <sub>u</sub>	6.70		
UNDRAINED SHEAR STRENGTH, T/SQ FT		s <sub>u</sub>			
SENSITIVITY RATIO		S <sub>i</sub>			
INITIAL SPECIMEN DIAMETER, IN		D <sub>o</sub>	1.43		
INITIAL SPECIMEN HEIGHT, IN.		H <sub>o</sub>	3.01		
CLASSIFICATION Clayey sand, SC					
LL 28		PL 14		PI 14	
				G <sub>s</sub> 2.63	
REMARKS Dark brown and tan Too brittle for Torvane Highly calcareous			PROJECT MINNESOTA RIVER: IA-90-04-ED-GH		
			AREA MRD LAB NO. : 90-135		
			BORING NO. 89-112MU		SAMPLE NO. S-1
			DEPTH EL 3.5'-5.5'		DATE
UNCONFINED COMPRESSION TEST REPORT					



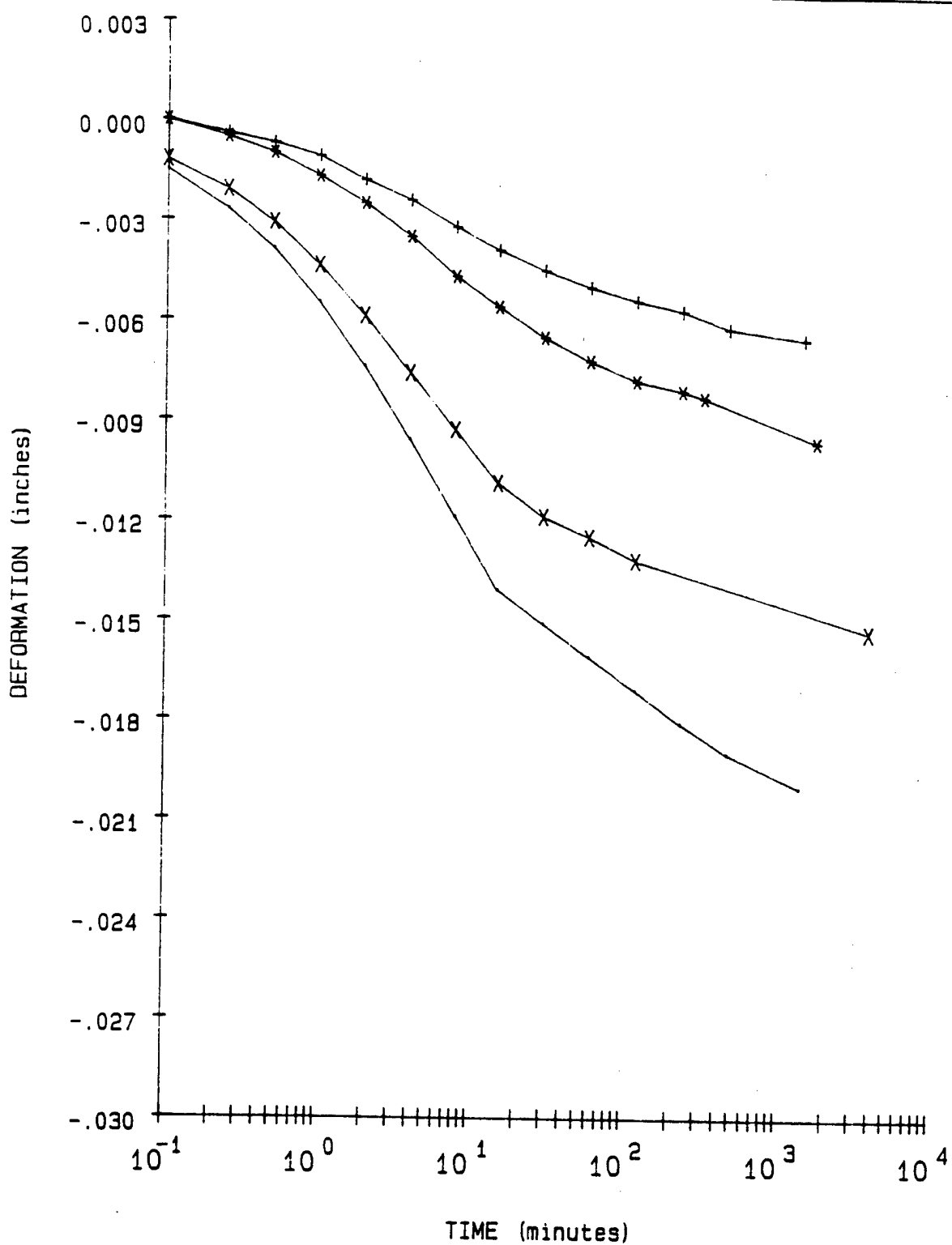
LL = 35	PL = 14	PI = 21	Gs = 2.69	NAT W =	%
CLASSIFICATION Sandy clay, CL					
PROJECT MINNESOTA RIVER; IA-90-04-ED-6H					
BORING NO. 89-112 MU		MRD LAB NO. 90/135			
SAMPLE NO. S-1		DEPTH/ELEV 3.5'-5.5' (TOP)			

GRADATION CURVE





Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	1 in.	Water Content, $w_o$	28.6 %	$w_f$	26.6 %
Overburden Pressure, $p_o$	T/sq ft	Void Ratio, $e_o$	0.79	$e_f$	0.76		
Preconsol. Pressure, $p_c$	T/sq ft	Saturation, $S_o$	99 %	$S_f$	97 %		
Compression Index, $C_c$		Dry Density, $\gamma_d$	95.6 lb/ft <sup>3</sup>				
Classification	Lean clay, CL	$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec					
LL 44	$G_s$ 2.75	Project MINNESOTA RIVER: IA-90-04-ED-6H					
PL 19	$D_{10}$						
Remarks Brown, Gray, Dark Brown  Torvane=0.6 TSF  Slightly Calcareous		Area MRO LAB NO. 90/135					
		Boring No. 89-112 M			Sample No. S-3		
		Depth El 22'-24'			Date		
		<b>CONSOLIDATION TEST REPORT</b>					



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-112 MU

SAMPLE NO.

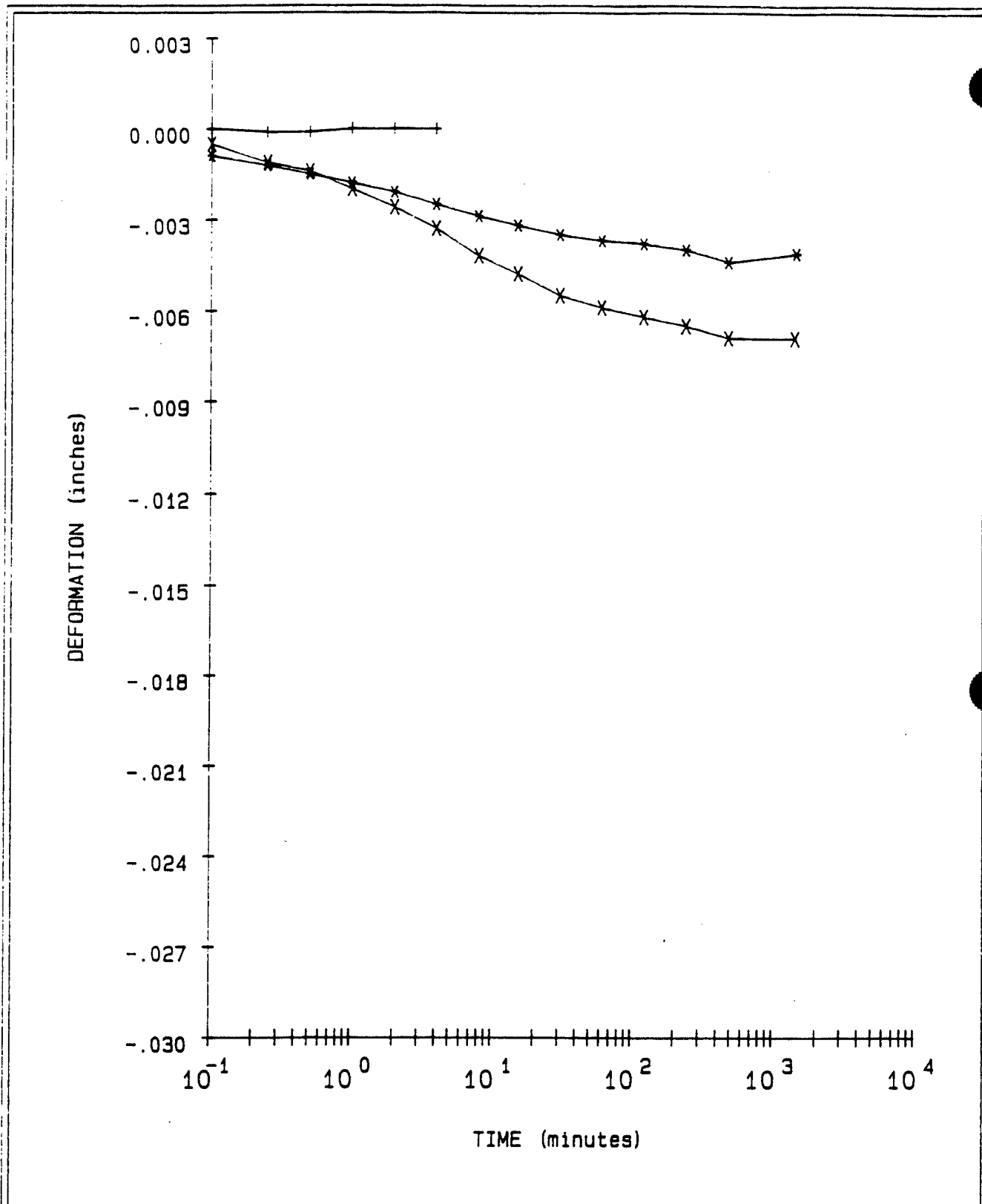
S-3

DEPTH/ELEV

22'-24'

MRD LAB NO.

90/135



LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-112 MU

SAMPLE NO.

S-3

DEPTH/ELEV

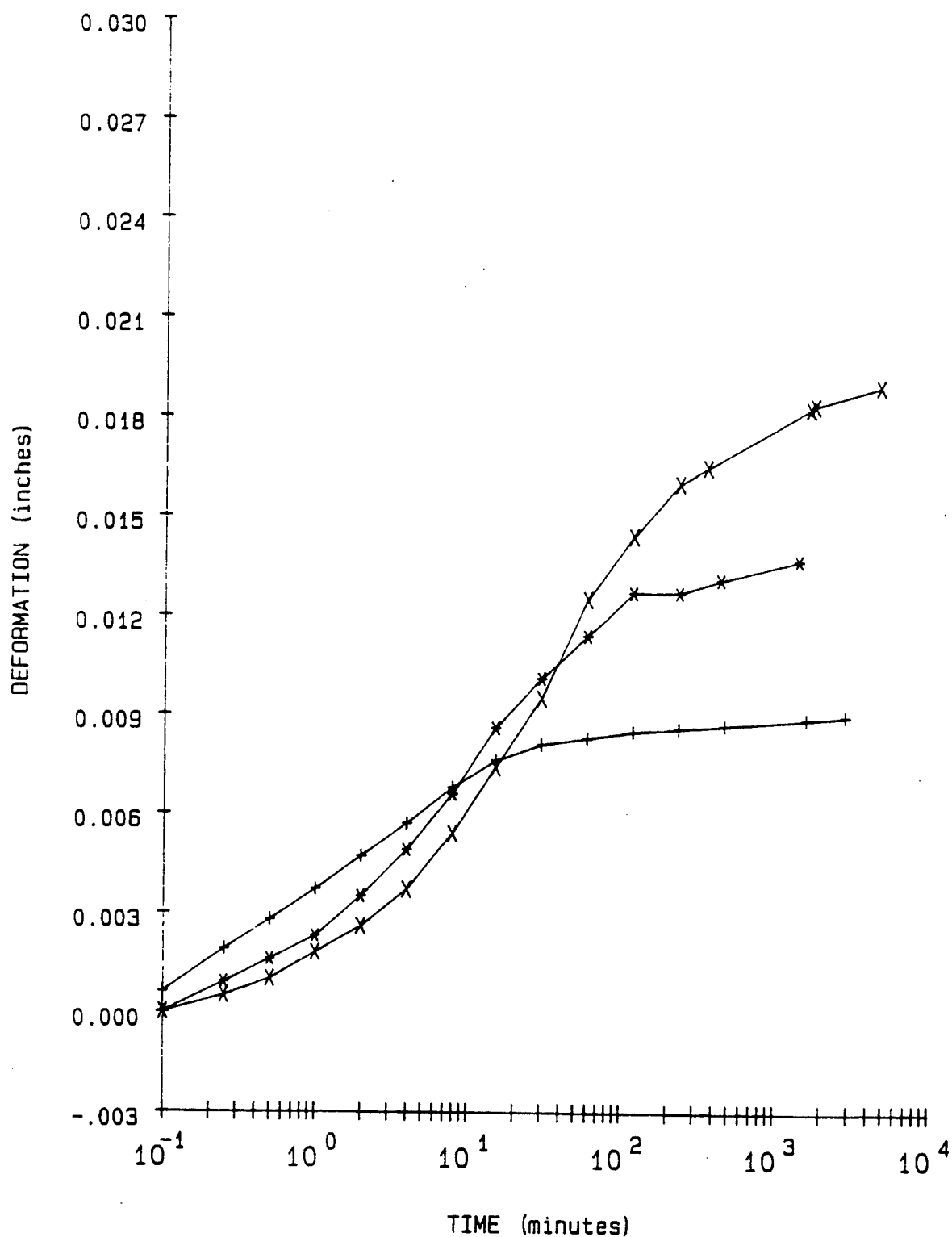
22'-24'

MRD LAB NO.

90/135

FIGURE 19





#### LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

#### BORING NO.

89-112 MU

#### SAMPLE NO.

S-3

#### DEPTH/ELEV

22'-24'

#### MRD LAB NO.

90/135

### Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-112 MU

Sample No. S-3

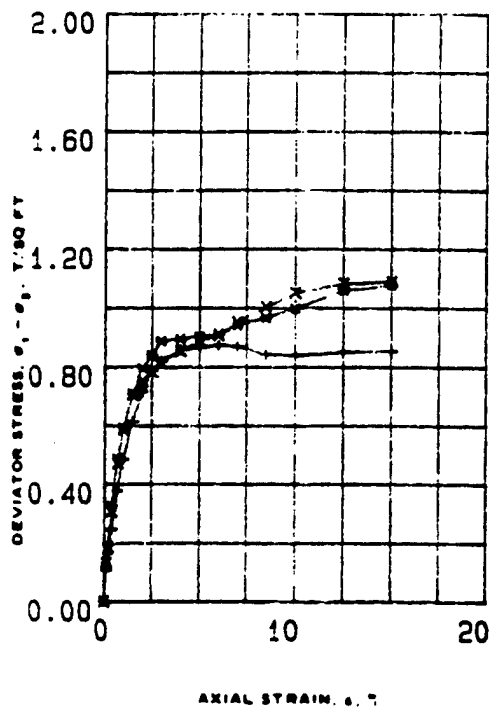
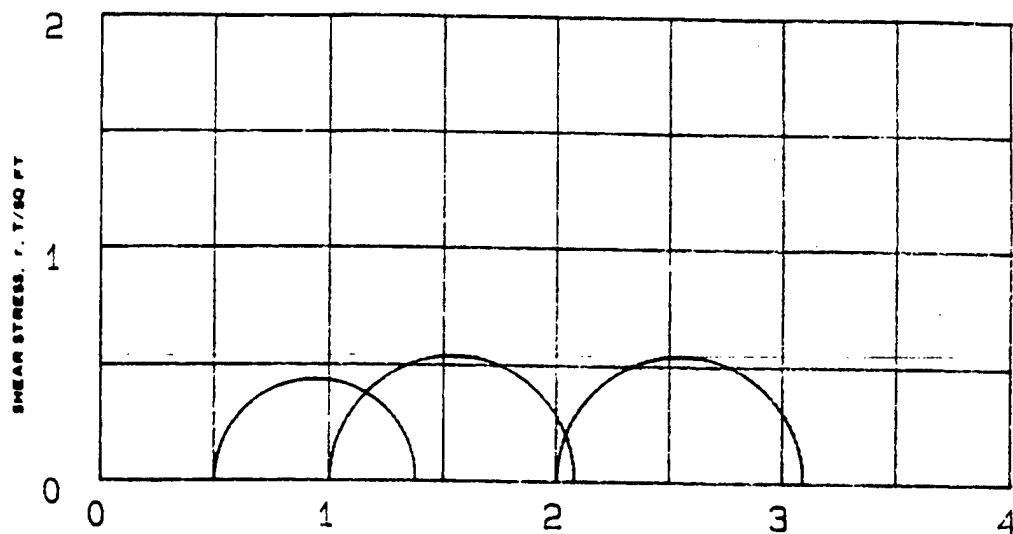
Depth/Elev 22'-24'

MRD Lab No. 90/135

$$\begin{aligned} G_s &= 2.75 \\ e_o &= 0.795 \\ 0.42e_o &= 0.334 \end{aligned}$$

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
28.6	362.1	95.6	0.795		99.0
26.6	362.1	95.6	0.795	0.10	92.1
26.6	362.1	96.0	0.787	0.25	93.0
26.6	362.1	96.7	0.775	0.50	94.5
26.6	362.1	97.3	0.763	1.00	95.9
26.6	362.1	98.3	0.746	2.00	98.1
26.6	362.1	99.8	0.719	4.00	100.0
26.6	362.1	102.0	0.683	8.00	100.0
26.6	362.1	101.0	0.699	2.00	100.0
26.6	362.1	99.6	0.724	0.50	100.0
26.6	362.1	97.6	0.758	0.10	96.6

Axial Strain (%)	Void Ratio
1	0.777
2	0.759
3	0.741
4	0.723
5	0.705
6	0.687
7	0.669
8	0.651
9	0.633



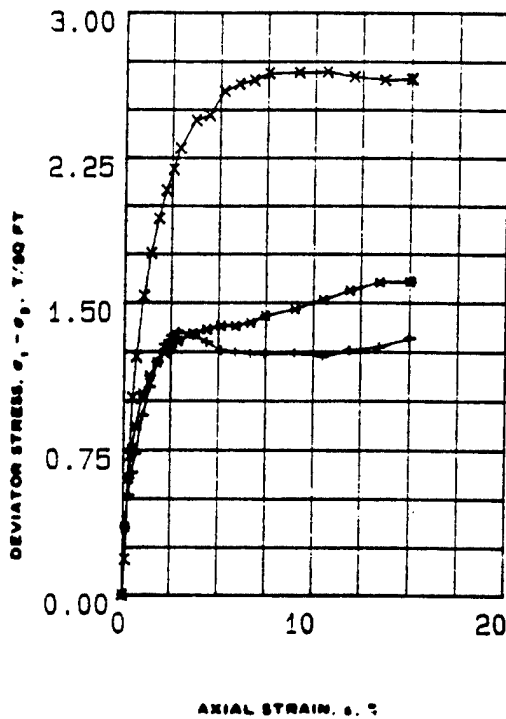
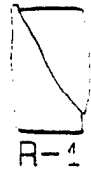
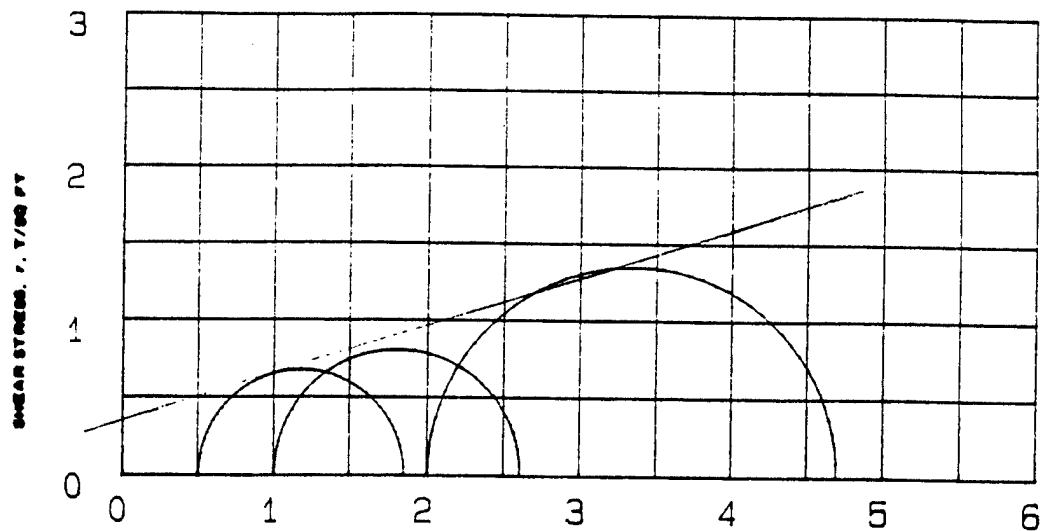
NORMAL STRESS,  $\sigma$ , T/50 FT  
 $c \sim 1100$   
 $\phi \sim 0$

SPECIMEN NO.		1 (+)	2 (X)	3 (X)	
INITIAL	WATER CONTENT, %	$w_0$ 27.4	28.5	28.3	
	DRY DENSITY LB/ CU FT	$\gamma_d$ 98.4	95.3	97.0	
	SATURATION, %	$s_0$ 100.0	98.0	100.0	
	VOID RATIO	$e_0$ 0.75	0.80	0.77	
BEFORE SHEAR	WATER CONTENT, %	$w_c$ 27.2	28.3	28.2	
	DRY DENSITY LB/ CU FT	$\gamma_{dc}$ 98.4	95.3	99.4	
	SATURATION, %	$s_c$ 100.0	97.0	100.0	
	VOID RATIO	$e_c$ 0.75	0.80	0.73	
FINAL BACK PRESSURE, T/50 FT		$u_0$ 0.0	0.0	0.0	
MINOR PRINCIPAL STRESS, T/50 FT		$\sigma_3$ 0.5	1.0	2.0	
MAXIMUM DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{max}$ 0.88	1.08	1.09	
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		$t_f$ 13.5	31.0	21.3	
ULTIMATE DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{ult}$ 0.85	1.08	1.09	
INITIAL DIAMETER, IN.		$D_0$ 1.42	1.42	1.42	
INITIAL HEIGHT, IN.		$H_0$ 3.00	3.00	2.98	

CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS Lean clay, CL

LL 44	PL 19	PI 25	$\omega_p$ 2.75	TYPE OF SPECIMEN	UNDISTURBED	TYPE OF TEST	Q
REMARKS: Brown, Gray, Dark Brown				PROJECT MINNESOTA RIVER; IA-90-04-ED-6H			
Torvane=0.6 TSF							
Slightly Calcareous				BORING NO.	89-112 MU	SAMPLE NO.	S-3
				DEPTH ELEV	22'-24'		
				LABORATORY	90/135	DATE	
TRIAXIAL COMPRESSION TEST REPORT							



NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (*)	3 (X)
INITIAL	WATER CONTENT, %	29.3	28.1	28.5
	DRY DENSITY LB/ CU FT	95.1	96.5	95.6
	SATURATION, %	100	99	99
	VOID RATIO	.81	.78	.8
BEFORE SHEAR	WATER CONTENT, %	30.2	27.8	26.7
	DRY DENSITY LB/ CU FT	95.9	98.4	99.5
	SATURATION, %	100	100	100
	VOID RATIO	.79	.74	.73
	FINAL BACK PRESSURE, T/50 FT	4.103	4.103	4.103
	MINOR PRINCIPAL STRESS, T/50 FT	.5	1	2
MAXIMUM DEVIATOR STRESS, T/50 FT		1.350	1.608	2.697
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		240	1191	840
ULTIMATE DEVIATOR STRESS, T/50 FT		1.317	1.608	2.680
INITIAL DIAMETER, IN.		1.38	1.39	1.4
INITIAL HEIGHT, IN.		3	3	2.99

CONTROLLED STRAIN TEST

DESCRIPTION OF SPECIMENS Lean clay, CL

B-value 1.0 1.0 1.0

LL 44 PL 19 PI 25 G. 2.75

TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST ABAR

REMARKS: Brown, Gray, Dark Brown

PROJECT MINNESOTA RIVER: IA-90-04-ED-6H

Torvane=0.6 TSF

Slightly Calcareous

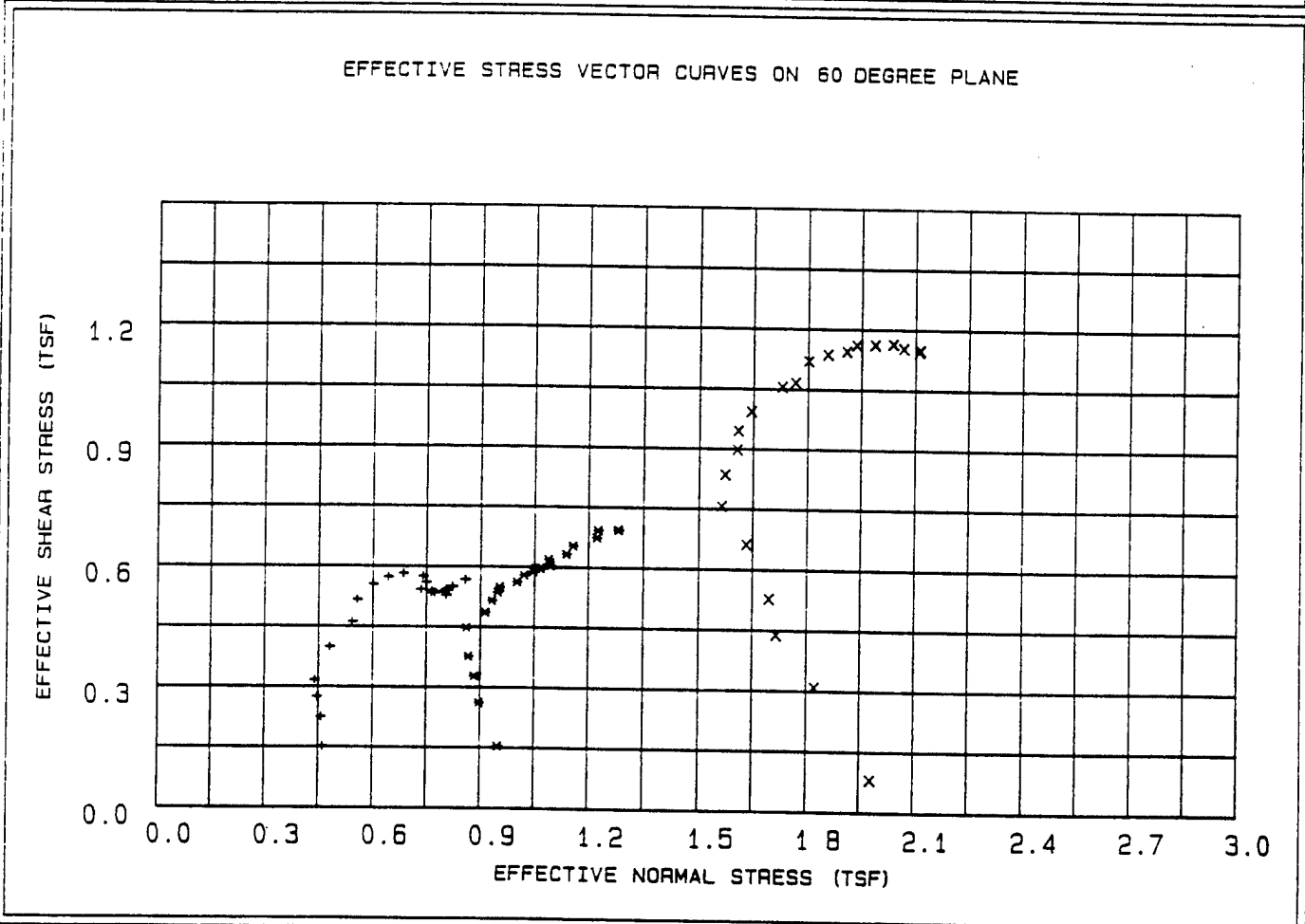
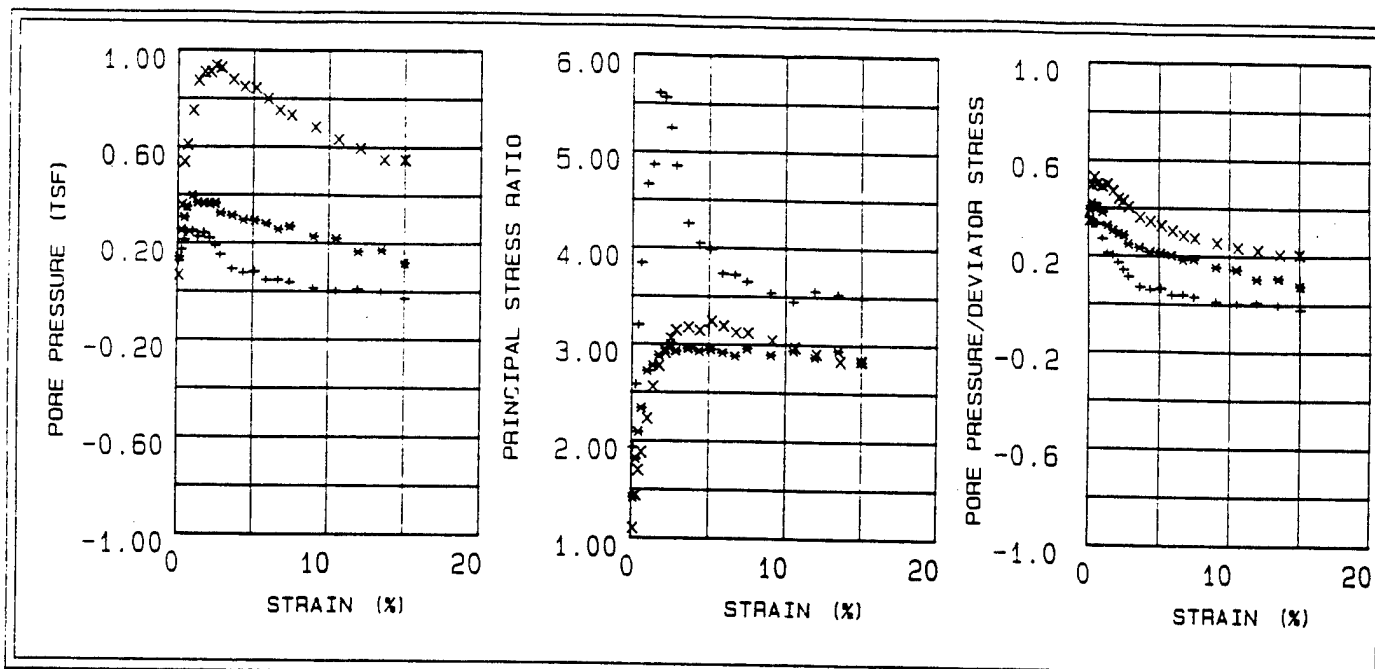
BORING NO 89-112 MU SAMPLE NO. S-3

DEPTH FLEV 22'-24'

LABORATORY 90/135

DATE

TRIAXIAL COMPRESSION TEST REPORT



LEGEND

+ = .5 TSF

\* = 1 TSF

x = 2 TSF

PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
BORING NO.	89-112 MU
SAMPLE NO.	S-3
DEPTH/ELEV	22'-24'
MRD LAB NO.	90/135

FIGURE 23

Table 7 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
Boring Number : 89-112 MU  
Sample Number : S-3  
Depth : 22'-24'  
Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.348	0.124	1.926	0.356	0.462	0.150
30	0.31	0.518	0.171	2.578	0.331	0.457	0.224
45	0.48	0.634	0.212	3.199	0.334	0.445	0.274
60	0.65	0.731	0.242	3.837	0.332	0.439	0.315
90	1.03	0.923	0.248	4.658	0.269	0.481	0.398
120	1.39	1.069	0.223	4.864	0.209	0.542	0.461
150	1.78	1.196	0.240	5.604	0.201	0.556	0.516
180	2.16	1.286	0.218	5.559	0.170	0.600	0.555
210	2.52	1.331	0.186	5.242	0.140	0.643	0.574
240	2.86	1.350	0.149	4.848	0.111	0.685	0.583
300	3.65	1.332	0.090	4.247	0.068	0.740	0.575
360	4.37	1.297	0.073	4.039	0.057	0.748	0.560
420	5.11	1.255	0.078	3.975	0.063	0.733	0.542
480	5.88	1.246	0.043	3.729	0.035	0.765	0.538
540	6.67	1.237	0.044	3.715	0.036	0.762	0.534
600	7.44	1.236	0.033	3.646	0.027	0.773	0.534
720	9.00	1.242	0.010	3.533	0.008	0.798	0.536
840	10.49	1.224	-0.001	3.443	0.000	0.804	0.528
960	11.91	1.256	0.008	3.555	0.007	0.803	0.542
1080	13.44	1.274	-0.005	3.522	-0.004	0.821	0.550
1192	15.00	1.317	-0.030	3.484	-0.023	0.857	0.568
1192	15.00	1.317	-0.030	3.484	-0.023	0.857	0.568

Table 8 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-3  
 Depth : 22'-24'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.355	0.139	1.412	0.392	0.949	0.153
30	0.31	0.605	0.253	1.811	0.419	0.897	0.261
45	0.48	0.758	0.305	2.090	0.402	0.883	0.327
60	0.65	0.871	0.349	2.337	0.401	0.867	0.376
90	1.03	1.038	0.396	2.719	0.382	0.861	0.448
120	1.39	1.127	0.366	2.778	0.325	0.913	0.486
150	1.78	1.196	0.364	2.881	0.305	0.932	0.516
180	2.17	1.244	0.361	2.947	0.290	0.947	0.537
210	2.52	1.275	0.363	3.000	0.285	0.953	0.550
240	2.86	1.305	0.322	2.925	0.247	1.001	0.563
300	3.65	1.343	0.312	2.951	0.232	1.021	0.580
360	4.38	1.364	0.292	2.927	0.215	1.046	0.589
420	5.12	1.383	0.289	2.944	0.209	1.053	0.597
480	5.89	1.383	0.276	2.911	0.200	1.066	0.597
540	6.68	1.400	0.253	2.875	0.182	1.094	0.604
600	7.46	1.435	0.266	2.955	0.186	1.089	0.619
720	9.02	1.467	0.224	2.889	0.153	1.139	0.633
840	10.51	1.516	0.217	2.935	0.143	1.158	0.654
960	11.93	1.564	0.164	2.870	0.105	1.223	0.675
1080	13.47	1.606	0.171	2.937	0.107	1.227	0.693
1190	15.00	1.608	0.117	2.822	0.074	1.281	0.694
1190	15.00	1.608	0.117	2.822	0.074	1.281	0.694

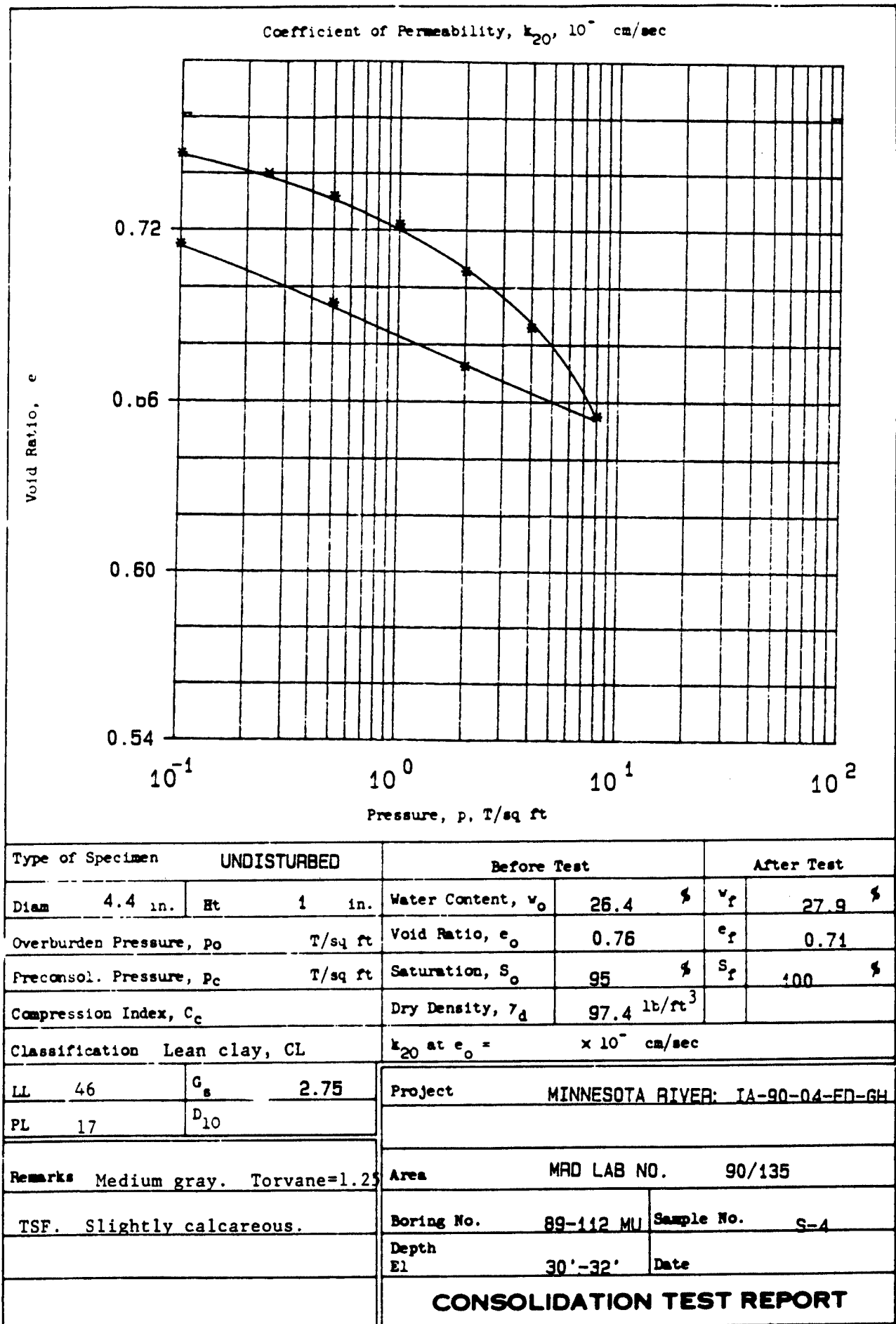
Table 9 - Triaxial  $\bar{R}$  Test Results

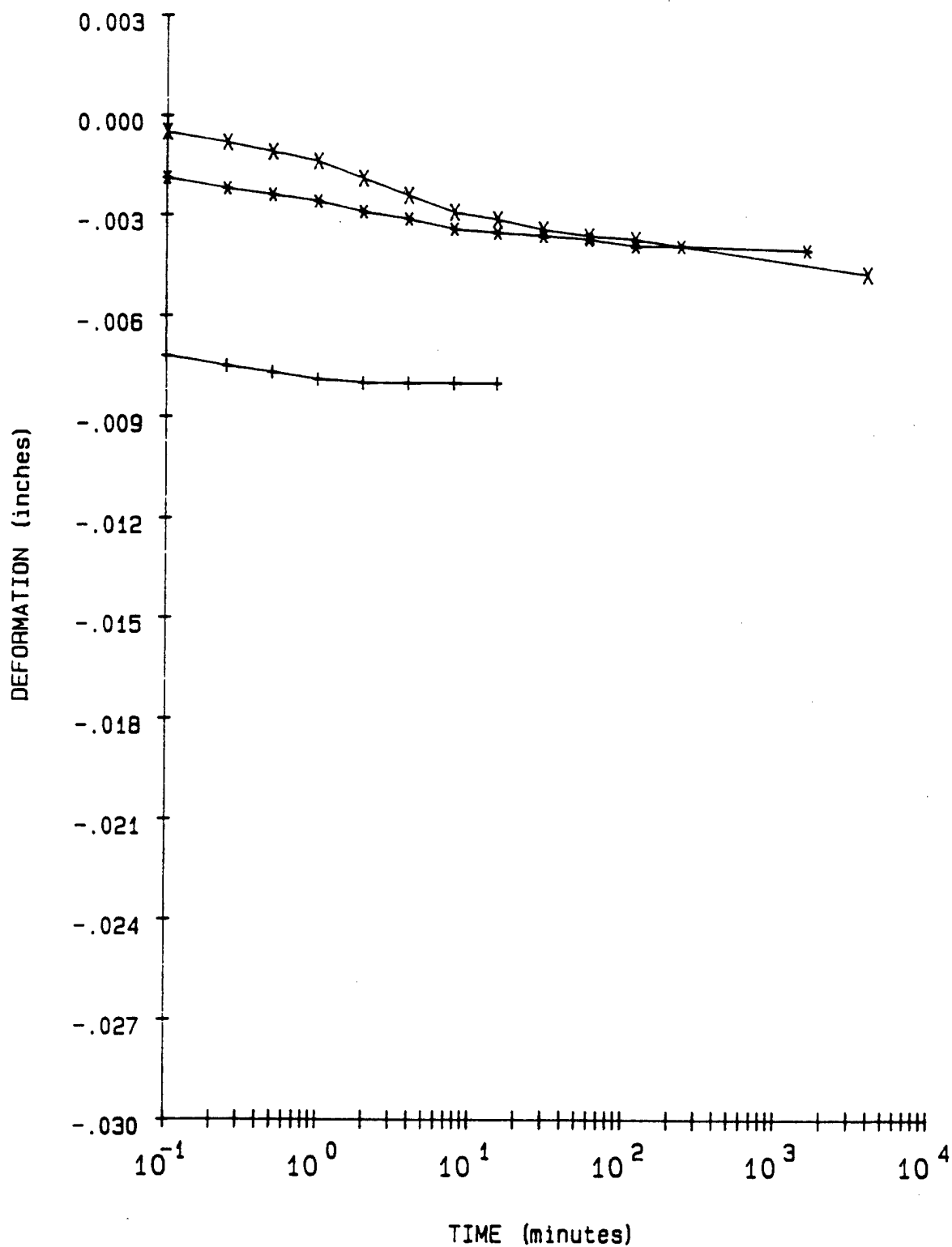
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-3  
 Depth : 22'-24'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.186	0.065	1.096	0.347	1.981	0.080
30	0.32	0.717	0.354	1.436	0.495	1.823	0.309
45	0.48	1.015	0.536	1.694	0.528	1.715	0.438
60	0.66	1.224	0.608	1.880	0.497	1.695	0.528
90	1.04	1.533	0.749	2.226	0.489	1.631	0.662
120	1.41	1.753	0.872	2.554	0.498	1.562	0.756
150	1.80	1.934	0.908	2.772	0.470	1.571	0.835
180	2.19	2.080	0.910	2.908	0.438	1.605	0.898
210	2.55	2.190	0.935	3.057	0.428	1.607	0.945
240	2.89	2.300	0.926	3.143	0.403	1.643	0.993
300	3.69	2.445	0.877	3.177	0.359	1.728	1.055
360	4.42	2.471	0.847	3.143	0.343	1.765	1.066
420	5.18	2.596	0.842	3.242	0.325	1.801	1.120
480	5.96	2.634	0.797	3.190	0.303	1.855	1.137
540	6.75	2.654	0.749	3.122	0.283	1.908	1.145
600	7.53	2.690	0.730	3.117	0.272	1.936	1.161
720	9.11	2.693	0.680	3.040	0.253	1.987	1.162
840	10.62	<del>2.697</del>	<del>0.631</del>	2.970	0.234	2.037	1.164
960	12.05	2.671	0.595	2.900	0.223	2.066	1.153
1080	13.61	2.654	0.547	2.826	0.206	2.110	1.145
1179	15.00	2.660	0.547	2.830	0.206	2.112	1.148
1179	15.00	2.660	0.547	2.830	0.206	2.112	1.148









LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-112 MU

SAMPLE NO.

S-4

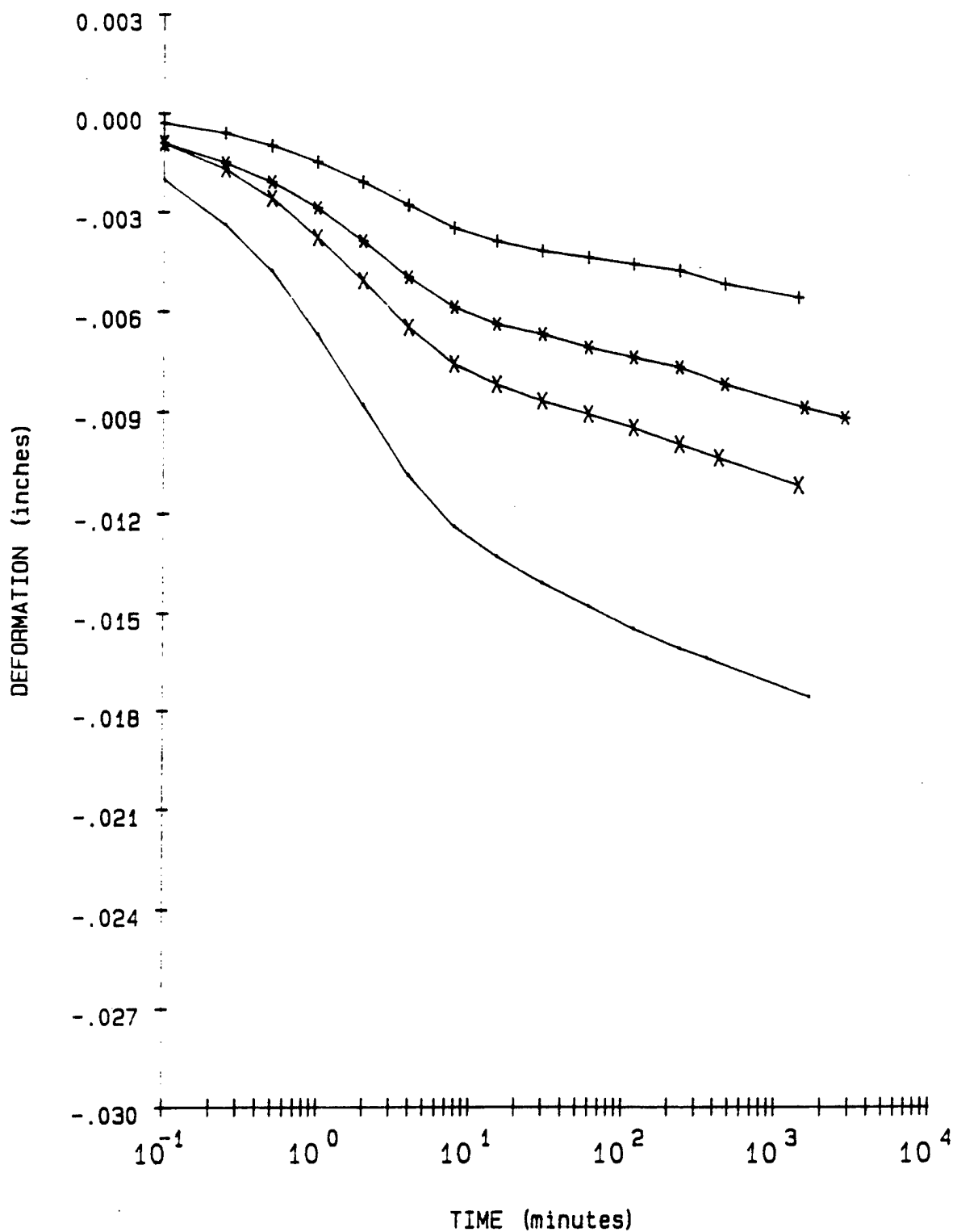
DEPTH/ELEV

30'-32'

MRD LAB NO.

90/135

FIGURE 2



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 X = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-112 MU

SAMPLE NO.

S-4

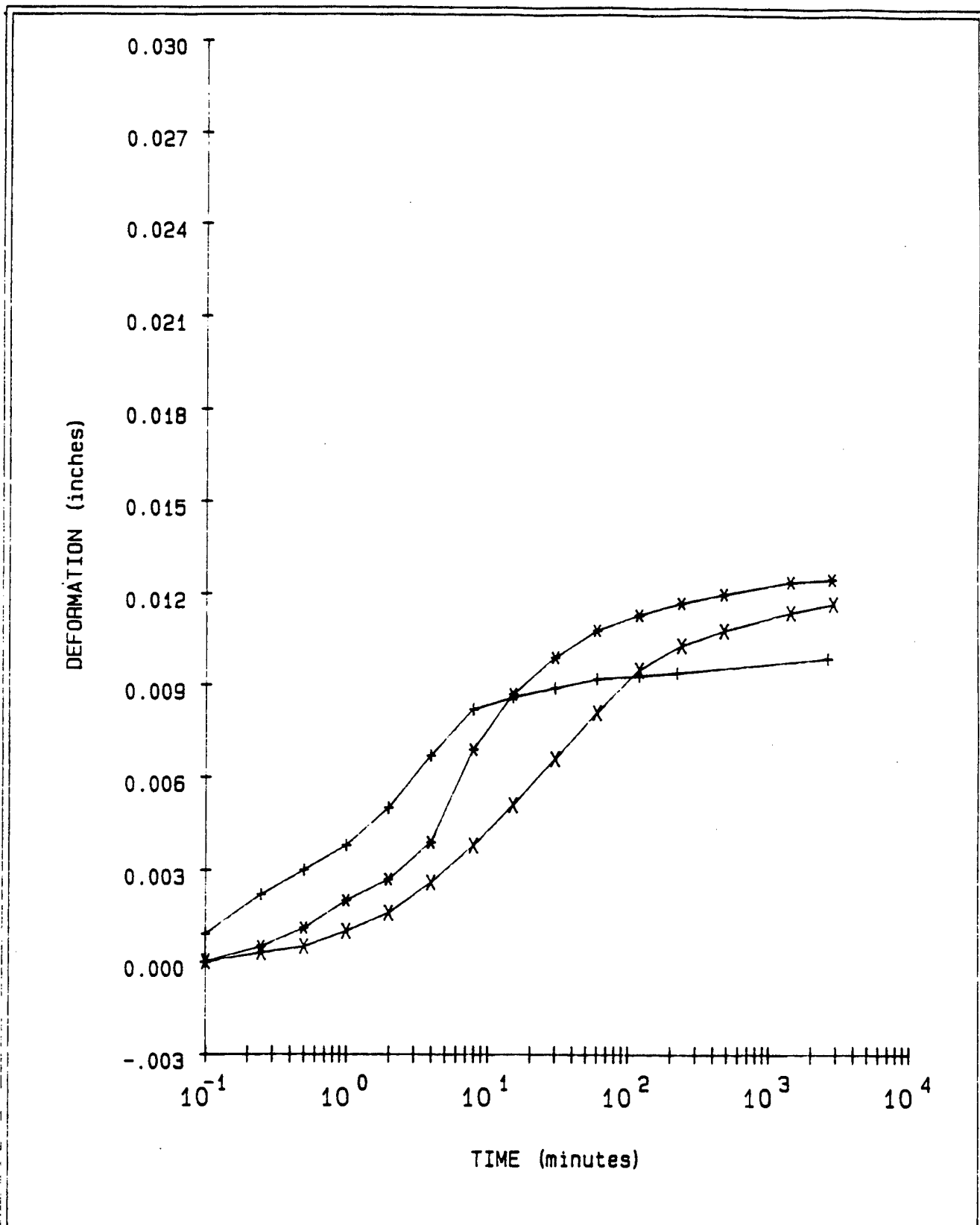
DEPTH/ELEV

30'-32'

MRO LAB NO.

90/135

FIGURE 3



#### LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 X = .1 TSF Rebound

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

#### BORING NO.

89-112 MU

#### SAMPLE NO.

S-4

#### DEPTH/ELEV

30'-32'

#### MRD LAB NO.

90/135

FIGURE 4

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-112 MU

Sample No. S-4

Depth/Elev 30'-32'

MRD Lab No. 90/135

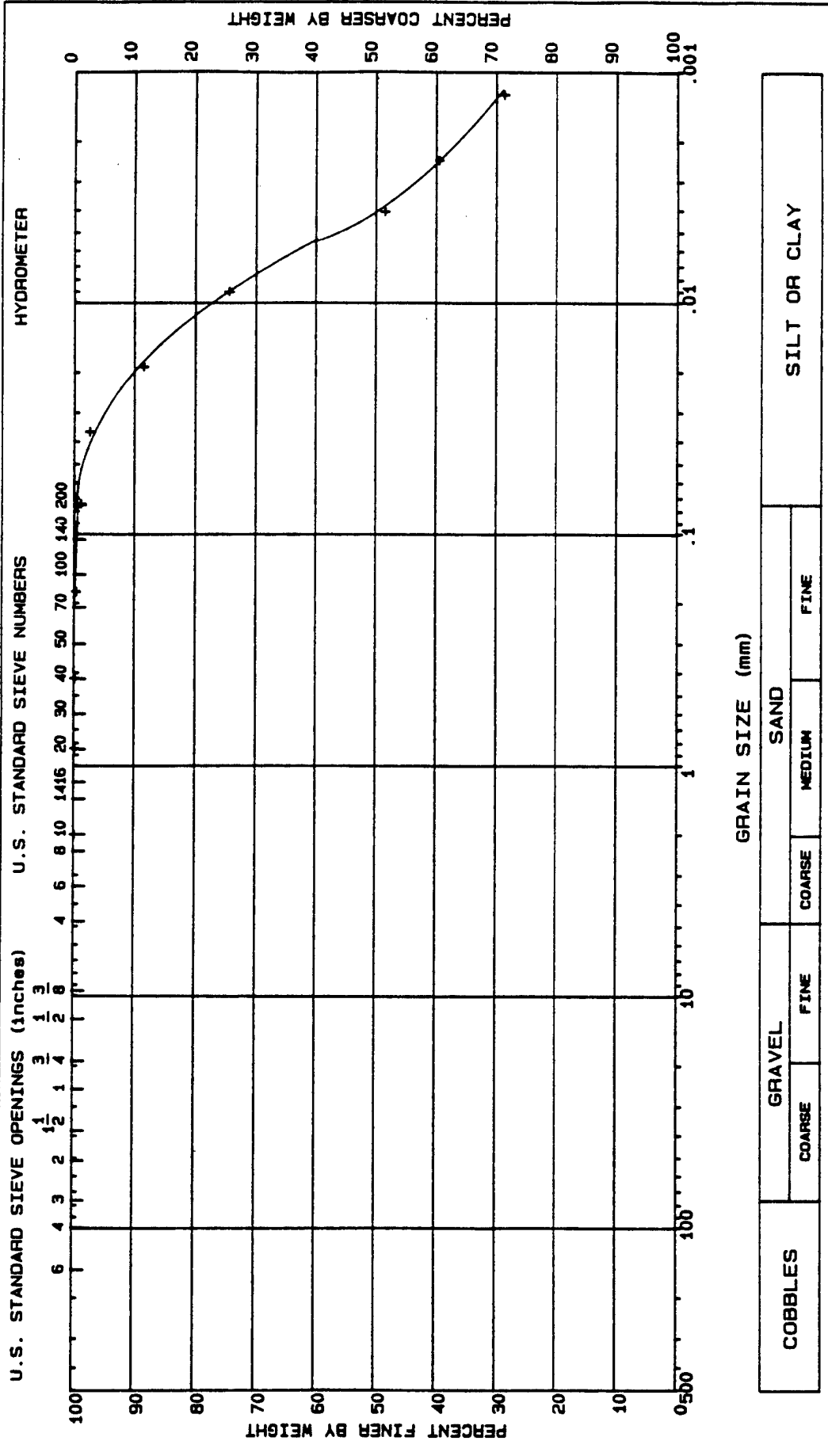
Gs = 2.75

eo = 0.761

0.42eo = 0.320

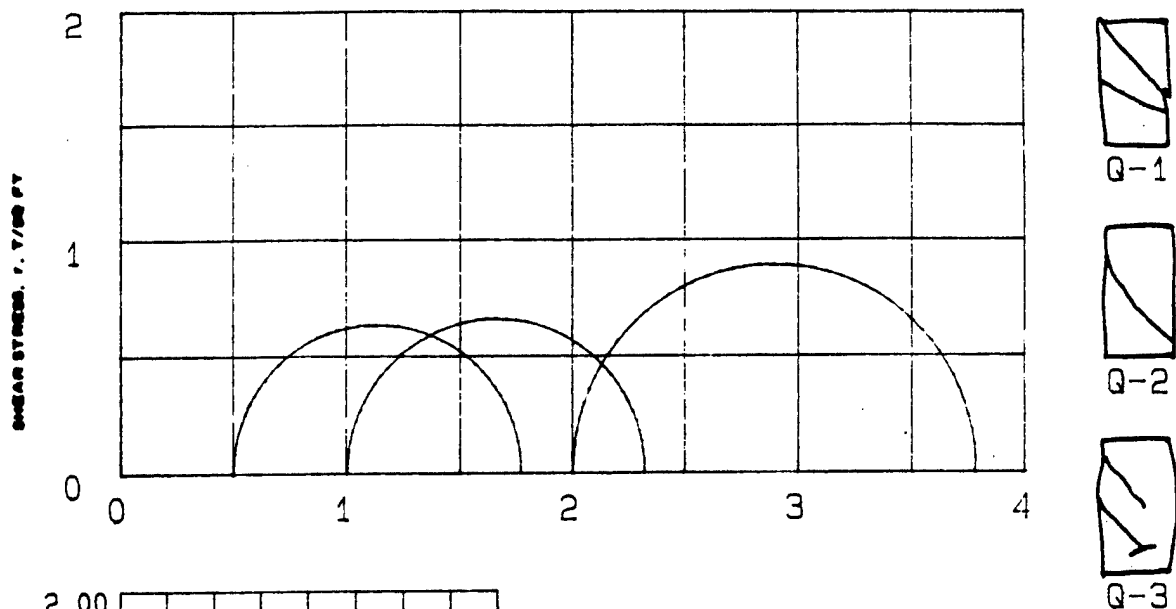
Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
26.4	395.8	97.4	0.761		95.3
27.9	395.8	98.2	0.747	0.10	100.0
27.9	395.8	98.6	0.740	0.25	100.0
27.9	395.8	99.1	0.732	0.50	100.0
27.9	395.8	99.7	0.722	1.00	100.0
27.9	395.8	100.6	0.706	2.00	100.0
27.9	395.8	101.8	0.686	4.00	100.0
27.9	395.8	103.7	0.655	8.00	100.0
7.9	395.8	102.6	0.672	2.00	100.0
27.9	395.8	101.3	0.694	0.50	100.0
27.9	395.8	100.1	0.715	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.744
2	0.726
3	0.708
4	0.691
5	0.673
6	0.655
7	0.638
8	0.620
9	0.603



LL - 46	PL - 17	PI - 29	Gs - 2.75	NAT w -	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-6H
CLASSIFICATION						BORING NO.	89-112 MU
						SAMPLE NO.	S-4
						DEPTH/ELEV	30'-32'
						MFD LAB NO.	90/135
GRADATION CURVE							

FIGURE 8

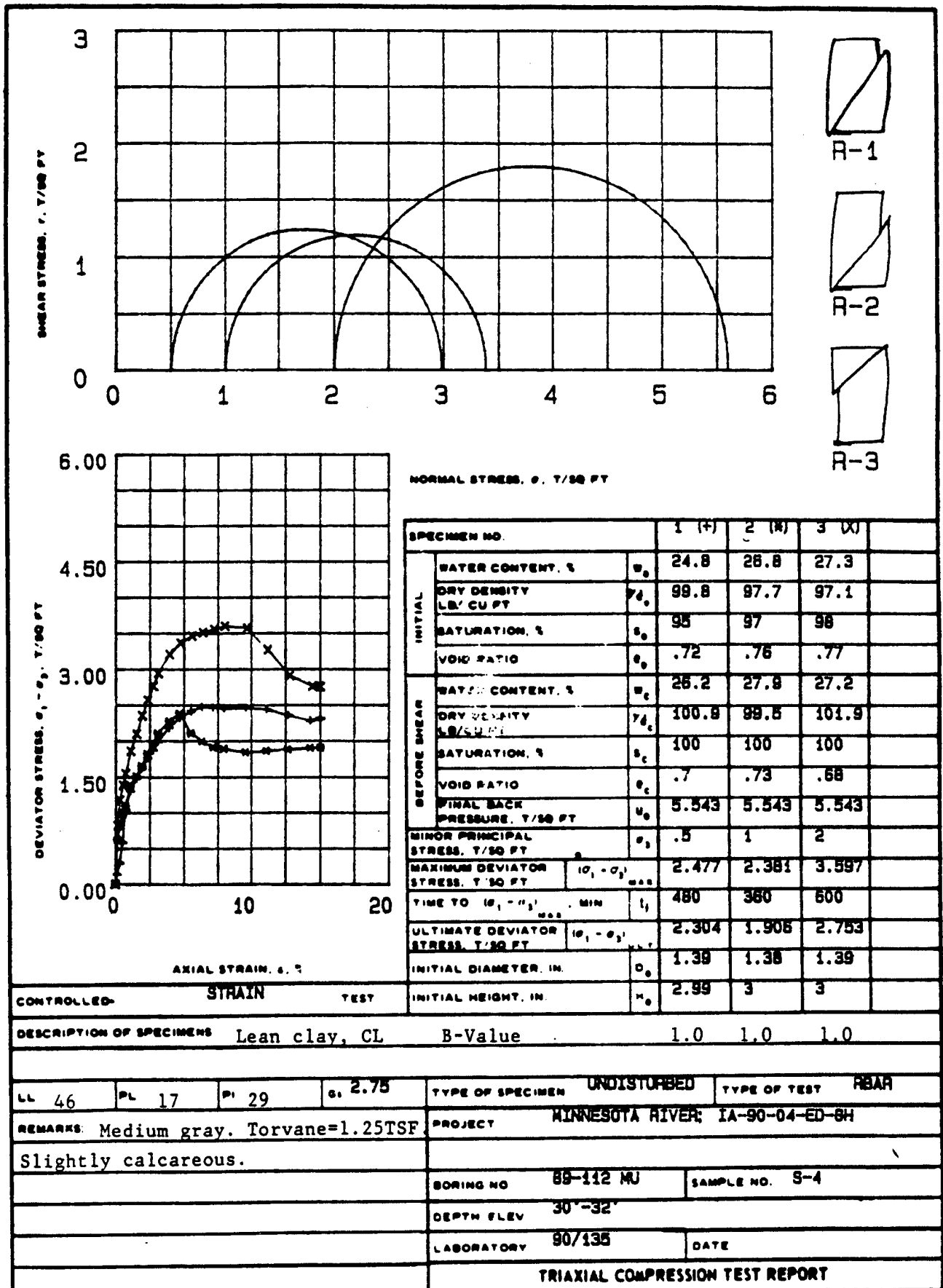


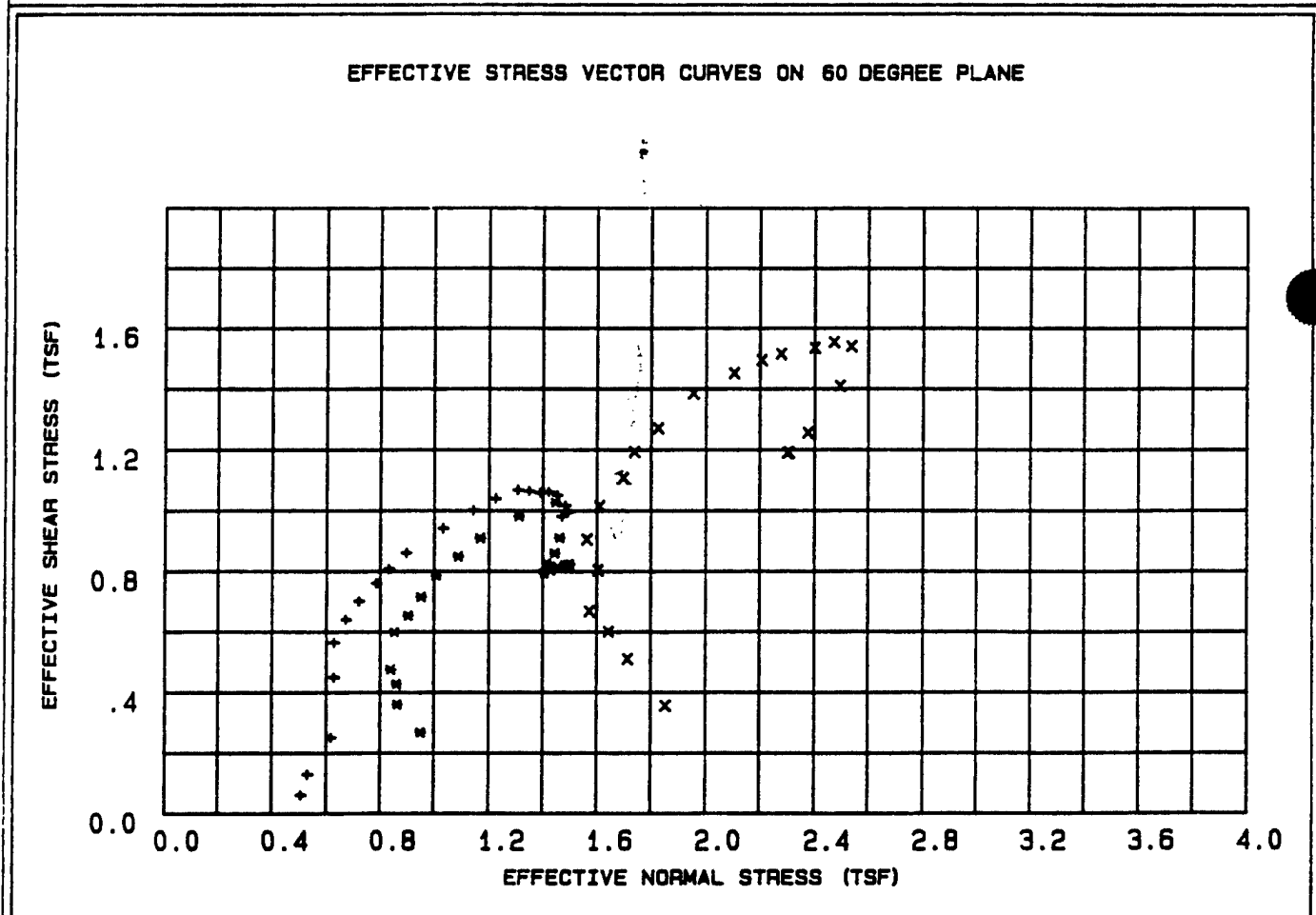
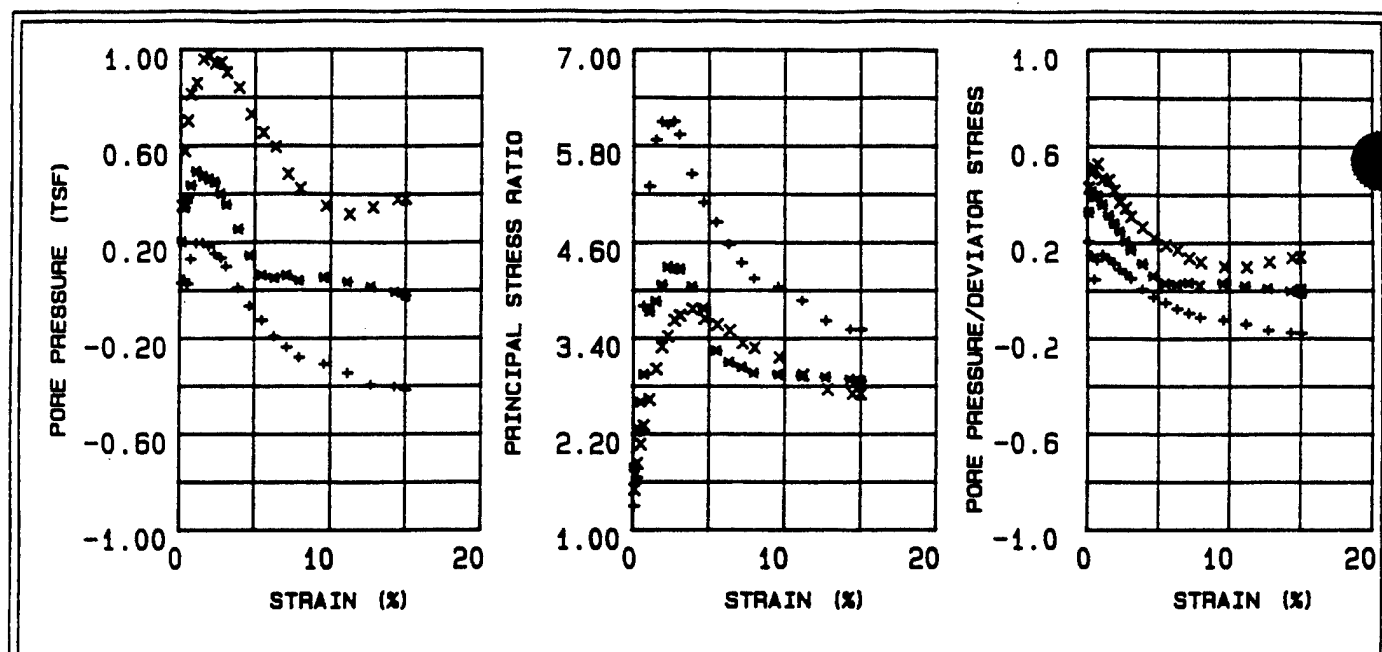
SPECIMEN NO.		1 (+)	2 (*)	3 (X)
INITIAL	WATER CONTENT, %	28.3	27.4	26.6
	DRY DENSITY LB/CU FT	96.1	97.5	99.0
	SATURATION, %	99.0	99.0	100.0
	VOID RATIO	0.79	0.76	0.73
BEFORE SHEAR	WATER CONTENT, %	28.2	27.3	26.5
	DRY DENSITY LB/CU FT	96.1	97.5	99.0
	SATURATION, %	99.0	98.0	99.0
	VOID RATIO	0.79	0.76	0.73
FINAL BACK PRESSURE, T/50 FT		0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		0.5	1.0	2.0
MAXIMUM DEVIATOR STRESS, T/50 FT		1.27	1.32	1.78
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$ , MIN		18.5	21.5	27.5
ULTIMATE DEVIATOR STRESS, T/50 FT		1.23	1.26	1.76
INITIAL DIAMETER, IN		1.42	1.42	1.42
INITIAL HEIGHT, IN		2.98	2.98	2.99

CONTROLLED-	STRAIN	TEST
DESCRIPTION OF SPECIMENS Lean clay, CL		
LL 46	PL 17	PI 29
REMARKS: Medium gray. Torvane=1.2TSF		
Slightly calcareous.		
BORING NO 89-112 MU		
DEPTH FLEV 30'-32'		
LABORATORY 90/135		
DATE		
TRIAXIAL COMPRESSION TEST REPORT		







<b>LEGEND</b> + = .5 TSF * = 1 TSF x = 2 TSF		<b>PROJECT</b> MINNESOTA RIVER: IA-90-04-ED-GH	
<b>BORING NO.</b> 89-112 MU		<b>SAMPLE NO.</b> S-4	
<b>DEPTH/ELEV</b> 30'-32'		<b>MRO LAB NO.</b> 90/135	

FIGURE 7

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-4  
 Depth : 30'-32'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.138	0.028	1.292	0.203	0.506	0.060
30	0.32	0.297	0.043	1.650	0.145	0.531	0.128
45	0.53	0.580	0.026	2.222	0.045	0.617	0.250
60	0.73	1.040	0.129	3.802	0.125	0.628	0.449
90	1.10	1.307	0.196	5.294	0.150	0.628	0.564
120	1.54	1.483	0.196	5.871	0.132	0.671	0.640
150	1.92	1.623	0.182	6.097	0.112	0.720	0.701
180	2.31	1.762	0.151	6.056	0.086	0.785	0.761
210	2.73	1.873	0.133	6.106	0.072	0.831	0.808
240	3.09	1.993	0.097	5.941	0.049	0.896	0.860
300	3.89	2.184	0.009	5.445	0.004	1.032	0.943
360	4.67	2.322	-0.068	5.091	-0.029	1.143	1.002
420	5.50	2.413	-0.128	4.843	-0.052	1.225	1.041
480	6.31	2.477	-0.194	4.567	-0.078	1.307	1.069
540	7.13	2.465	-0.239	4.337	-0.096	1.349	1.064
600	7.94	2.452	-0.281	4.138	-0.114	1.388	1.058
720	9.57	2.459	-0.311	4.034	-0.126	1.420	1.061
840	11.13	2.434	-0.349	3.866	-0.143	1.452	1.050
960	12.68	2.353	-0.400	3.615	-0.169	1.483	1.016
1080	14.29	2.271	-0.407	3.504	-0.179	1.469	0.980
1129	15.00	2.304	-0.420	3.505	-0.182	1.490	0.995
1129	15.00	2.304	-0.420	3.505	-0.182	1.490	0.995

Table 2 - Triaxial  $\bar{R}$  Test Results

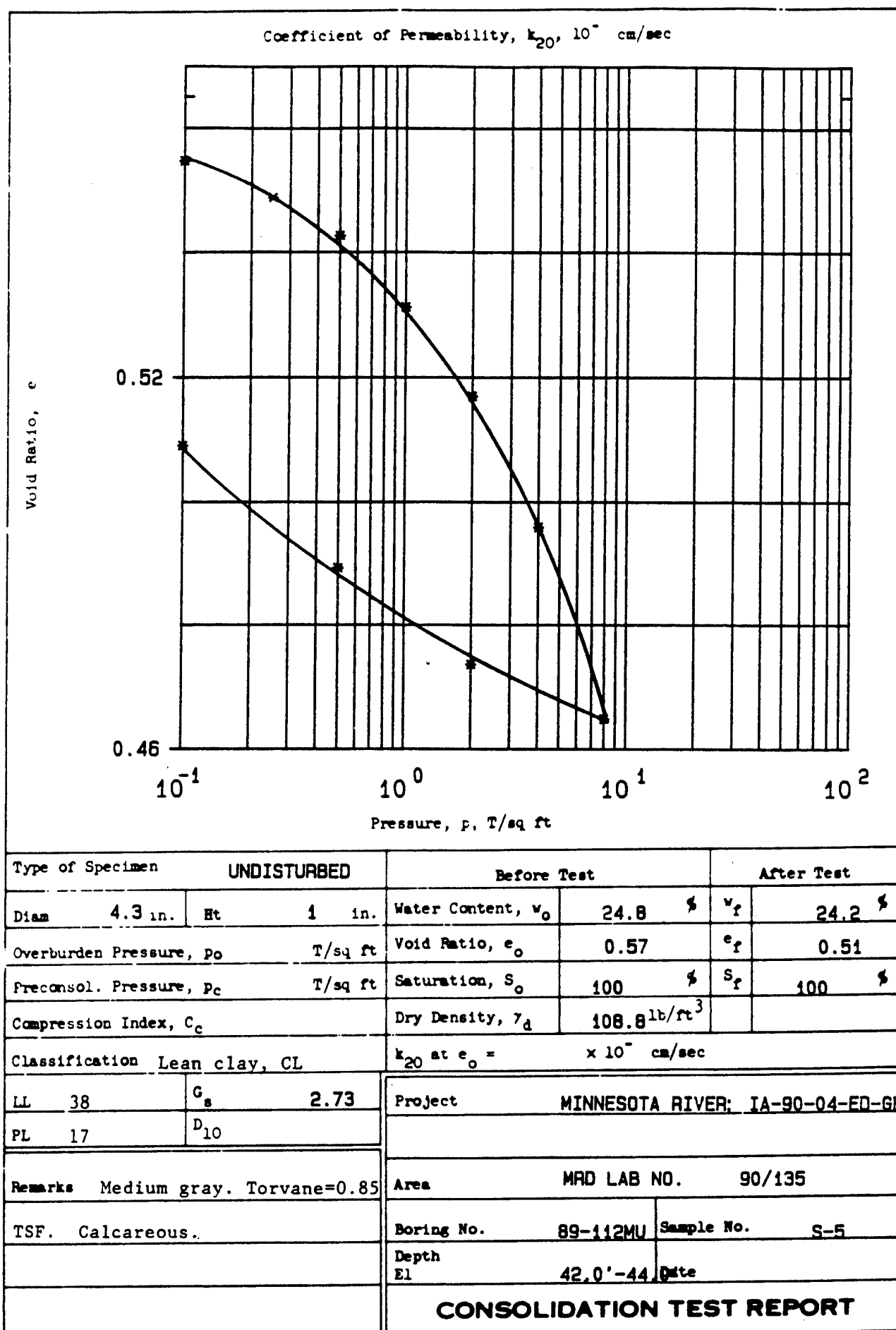
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-4  
 Depth : 30'-32'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.619	0.202	1.776	0.326	0.951	0.267
30	0.32	0.833	0.343	2.269	0.412	0.863	0.360
45	0.53	0.987	0.383	2.600	0.389	0.861	0.426
60	0.73	1.101	0.434	2.945	0.394	0.839	0.475
90	1.09	1.388	0.492	3.734	0.355	0.852	0.599
120	1.53	1.514	0.471	3.861	0.311	0.904	0.653
150	1.92	1.660	0.459	4.065	0.277	0.952	0.716
180	2.31	1.824	0.446	4.293	0.245	1.006	0.787
210	2.72	1.966	0.399	4.269	0.203	1.088	0.849
240	3.08	2.109	0.354	4.264	0.168	1.168	0.910
300	3.89	2.274	0.252	4.042	0.111	1.311	0.982
360	4.66	2.381	0.142	3.773	0.060	1.447	1.028
420	5.49	2.109	0.060	3.244	0.029	1.462	0.910
480	6.29	1.991	0.049	3.094	0.025	1.444	0.85
540	7.12	1.910	0.060	3.032	0.032	1.413	0.82
600	7.92	1.886	0.037	2.959	0.020	1.430	0.814
720	9.55	1.837	0.052	2.939	0.029	1.403	0.793
840	11.10	1.861	0.031	2.920	0.017	1.430	0.803
960	12.66	1.883	0.012	2.906	0.007	1.454	0.813
1080	14.26	1.901	-0.011	2.880	-0.005	1.482	0.820
1131	15.00	1.906	-0.026	2.858	-0.013	1.498	0.822
1131	15.00	1.906	-0.026	2.858	0.000	1.498	0.822

Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-4  
 Depth : 30'-32'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.822	0.350	1.498	0.427	1.853	0.355
30	0.32	1.179	0.578	1.829	0.490	1.714	0.509
45	0.54	1.390	0.702	2.071	0.505	1.642	0.600
60	0.74	1.547	0.812	2.302	0.525	1.571	0.668
90	1.11	1.860	0.858	2.629	0.462	1.603	0.803
120	1.55	2.097	0.958	3.012	0.457	1.561	0.905
150	1.94	2.351	0.973	3.289	0.414	1.609	1.015
180	2.33	2.568	0.939	3.421	0.366	1.697	1.108
210	2.75	2.764	0.946	3.623	0.343	1.738	1.193
240	3.12	2.943	0.903	3.683	0.307	1.826	1.270
300	3.93	3.206	0.840	3.764	0.262	1.954	1.384
360	4.72	3.362	0.727	3.641	0.217	2.105	1.451
420	5.56	3.461	0.651	3.565	0.188	2.206	1.494
480	6.37	3.509	0.593	3.493	0.169	2.276	1.514
540	7.20	3.553	0.480	3.337	0.135	2.400	1.534
600	8.01	3.597	0.420	3.277	0.117	2.471	1.553
720	9.66	3.566	<del>0.347</del>	3.157	0.098	2.536	1.539
840	11.23	3.263	0.314	2.935	0.097	2.494	1.408
960	12.81	2.906	0.344	2.754	0.119	2.375	1.254
1080	14.43	2.758	0.377	2.699	0.137	2.306	1.190
1119	15.00	2.753	0.381	2.701	0.139	2.300	1.188
1119	15.00	2.753	0.381	2.701	0.000	2.300	1.188



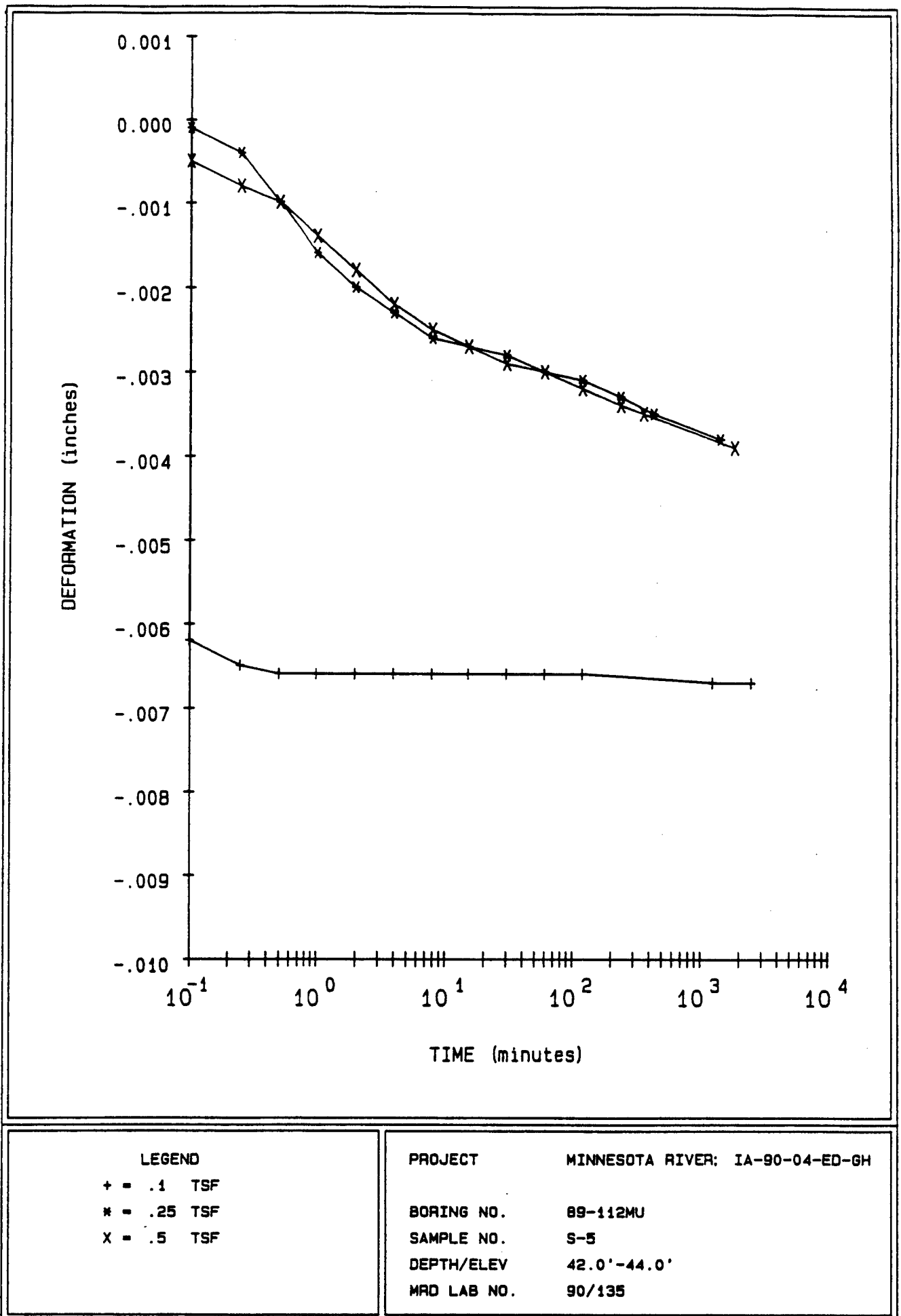
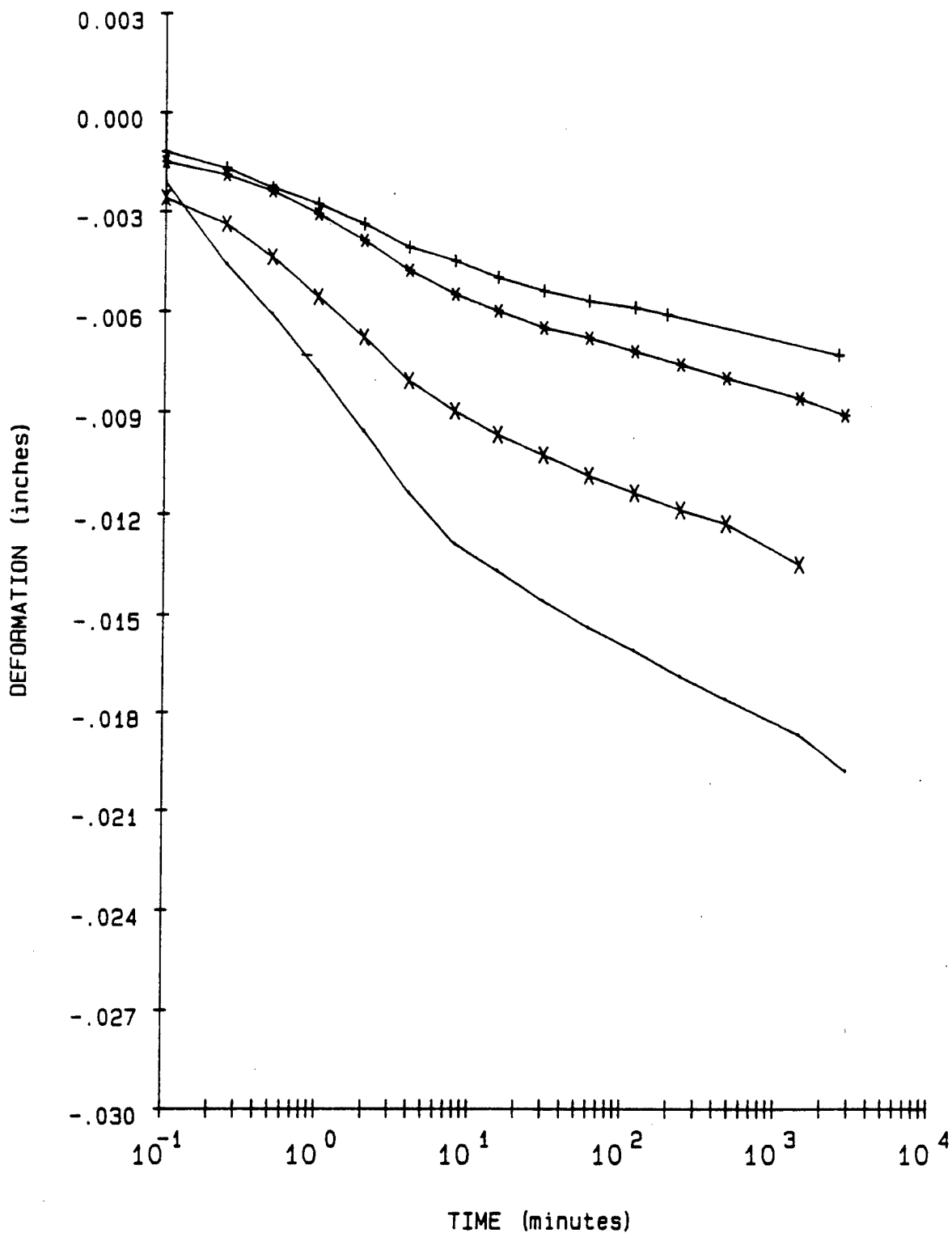


FIGURE 10



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-112MU

SAMPLE NO.

S-5

DEPTH/ELEV

42.0'-44.0'

MRD LAB NO.

90/135

FIGURE 11



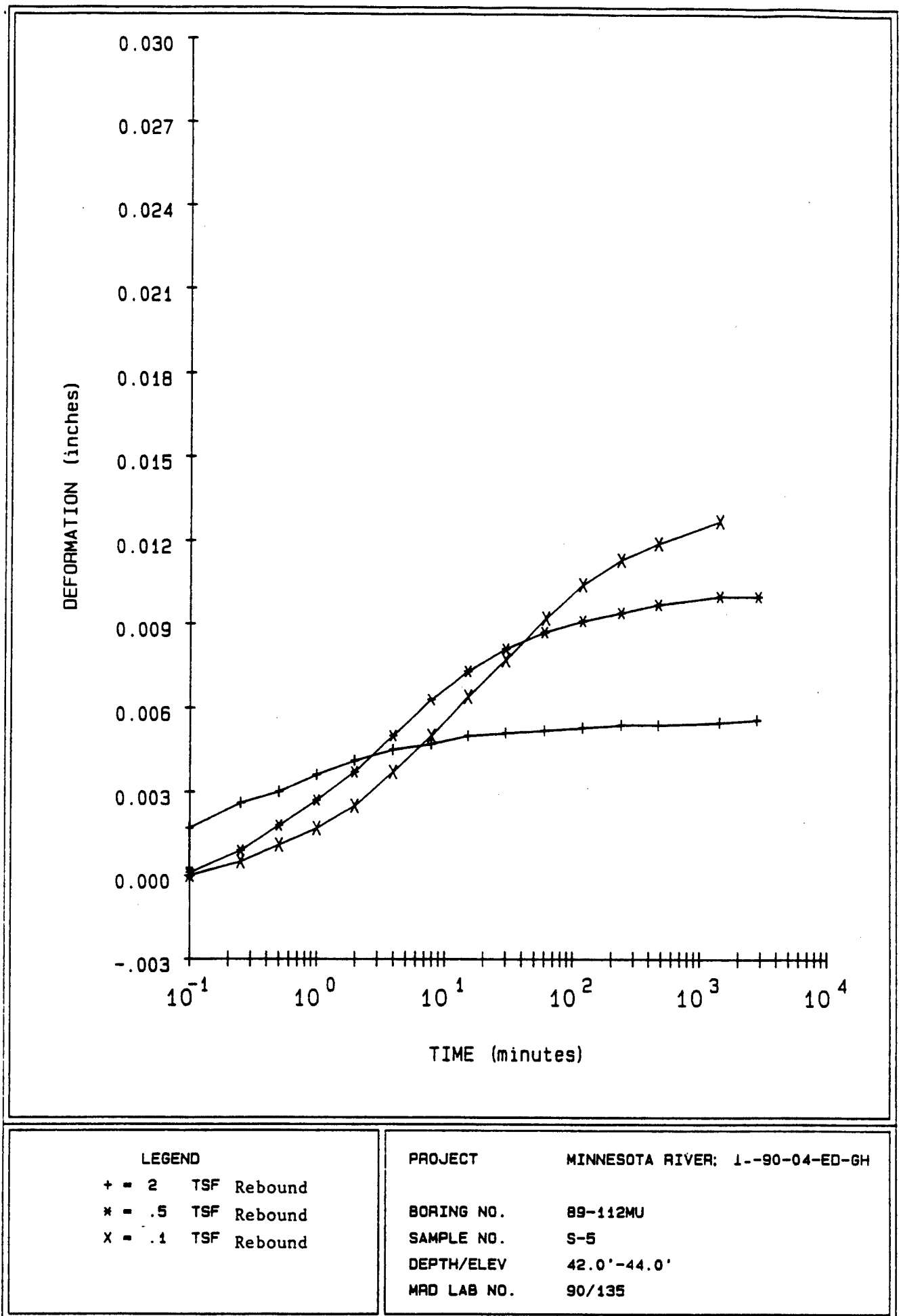


FIGURE 12

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-112MU

Sample No. S-5

Depth/Elev 42.0'-44.0'

MRD Lab No. 90/135

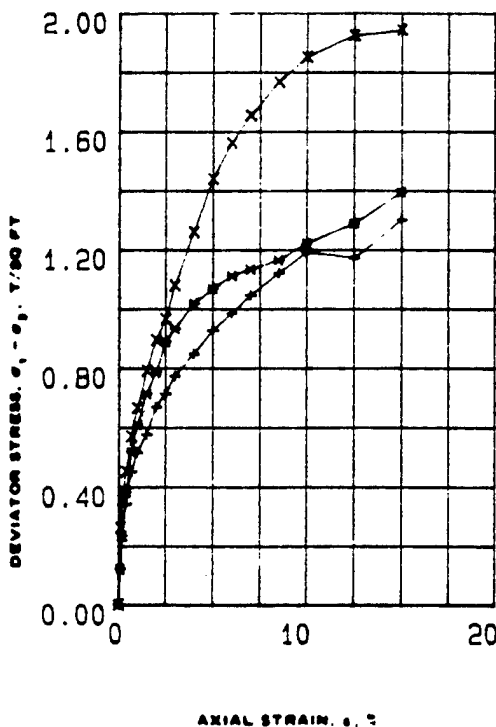
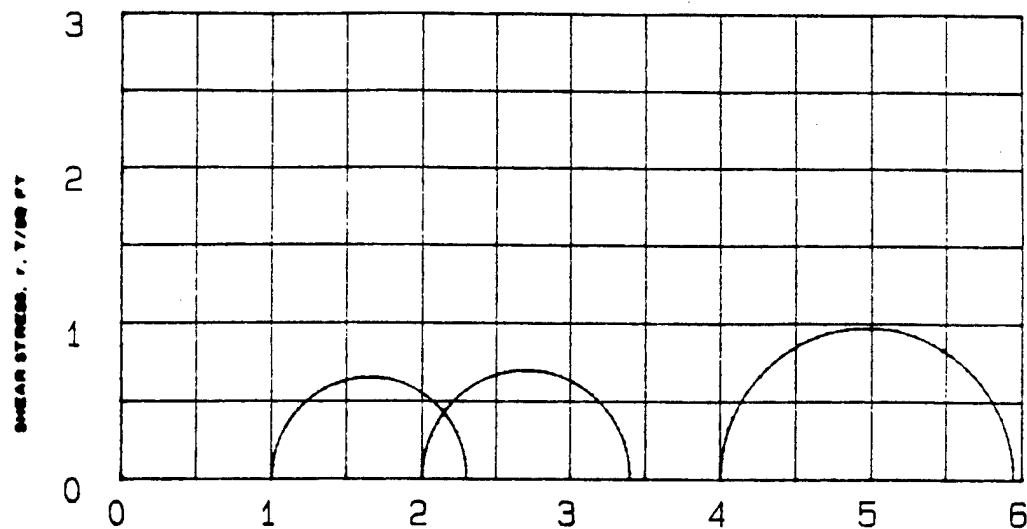
$G_s = 2.73$

$e_o = 0.565$

$0.42e_o = 0.237$

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
24.8	412.0	108.8	0.565		100.0
24.2	412.0	109.6	0.555	0.10	100.0
24.2	412.0	110.0	0.549	0.25	100.0
24.2	412.0	110.4	0.543	0.50	100.0
24.2	412.0	111.3	0.531	1.00	100.0
24.2	412.0	112.3	0.517	2.00	100.0
24.2	412.0	113.9	0.496	4.00	100.0
24.2	412.0	116.3	0.465	8.00	100.0
24.2	412.0	115.6	0.474	2.00	100.0
24.2	412.0	114.4	0.489	0.50	100.0
24.2	412.0	112.9	0.509	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.549
2	0.534
3	0.518
4	0.503
5	0.487
6	0.471
7	0.456
8	0.440
9	0.424

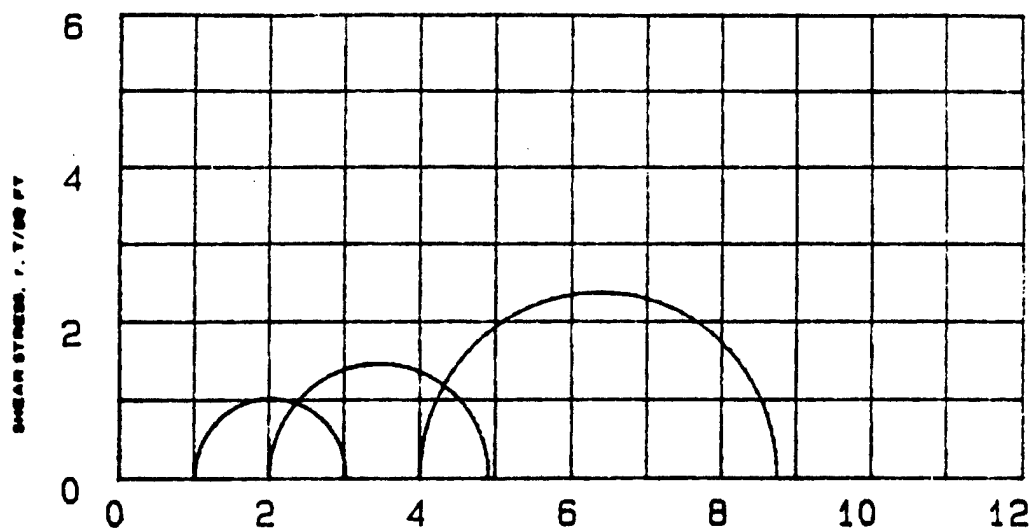


NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (*)	3 (X)
INITIAL	WATER CONTENT, %	25.4	24.1	24.2
	DRY DENSITY LB./CU. FT.	101.3	103.1	103.0
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.68	0.65	0.65
BEFORE SHEAR	WATER CONTENT, %	25.4	24.0	24.0
	DRY DENSITY LB./CU. FT.	101.3	103.1	103.2
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.68	0.65	0.65
FINAL BACK PRESSURE, T/50 FT		0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		1.0	2.0	4.0
MAXIMUM DEVIATOR STRESS, T/50 FT		1.30	1.40	1.94
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$ , MIN		31.8	31.8	31.5
ULTIMATE DEVIATOR STRESS, T/50 FT		1.30	1.40	1.94
INITIAL DIAMETER, IN.		1.42	1.42	1.42
INITIAL HEIGHT, IN.		2.98	2.98	3.00

CONTROLLED- STRAIN TEST  
DESCRIPTION OF SPECIMENS Lean clay, CL

LL 38	PL 17	PI 21	G <sub>s</sub> 2.73	TYPE OF SPECIMEN	UNDISTURBED	TYPE OF TEST	Q
REMARKS: Medium gray. Torvane=0.85TSF.				PROJECT MINNESOTA RIVER; IA-90-04-ED-GH			
Calcareous.							
				BORING NO	89-112MU	SAMPLE NO.	S-5
				DEPTH ELEV	42'-44'		
				LABORATORY	90/135	DATE	
TRIAXIAL COMPRESSION TEST REPORT							



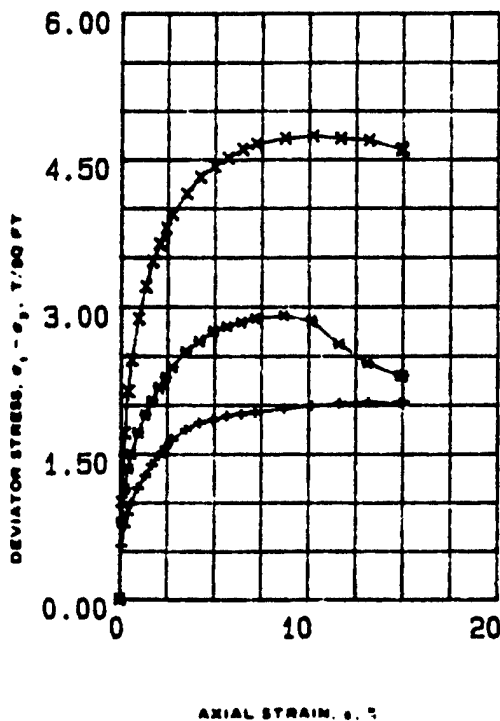
R-1



R-2



R-3



NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (H)	3 (X)
INITIAL	WATER CONTENT, %	25.1	25.8	24.4
	DRY DENSITY LB/CU FT	101.3	99.7	101.9
	SATURATION, %	100	98	99
	VOID RATIO	.68	.71	.67
BEFORE SHEAR	WATER CONTENT, %	26.1	27	24.3
	DRY DENSITY LB/CU FT	102.7	102.4	105.9
	SATURATION, %	100	100	100
	VOID RATIO	.68	.67	.61
FINAL BACK PRESSURE, T/50 FT		4.103	4.103	4.103
MINOR PRINCIPAL STRESS, T/50 FT		1	2	4
MAXIMUM DEVIATOR STRESS, T/50 FT		2.024	2.911	4.742
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		1080	720	840
ULTIMATE DEVIATOR STRESS, T/50 FT		2.023	2.293	4.598
INITIAL DIAMETER, IN.		1.39	1.4	1.39
INITIAL HEIGHT, IN.		2.98	2.98	2.98

CONTROLLED STRAIN TEST

DESCRIPTION OF SPECIMENS Lean clay, CL B-Value 1.0 1.0 1.0

LL 38 PL 17 PI 21 G<sub>s</sub> 2.73

TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST RBAH

REMARKS: Medium gray. Torvane=0.85TSF.

PROJECT MINNESOTA RIVER IA-90-04-ED-8H

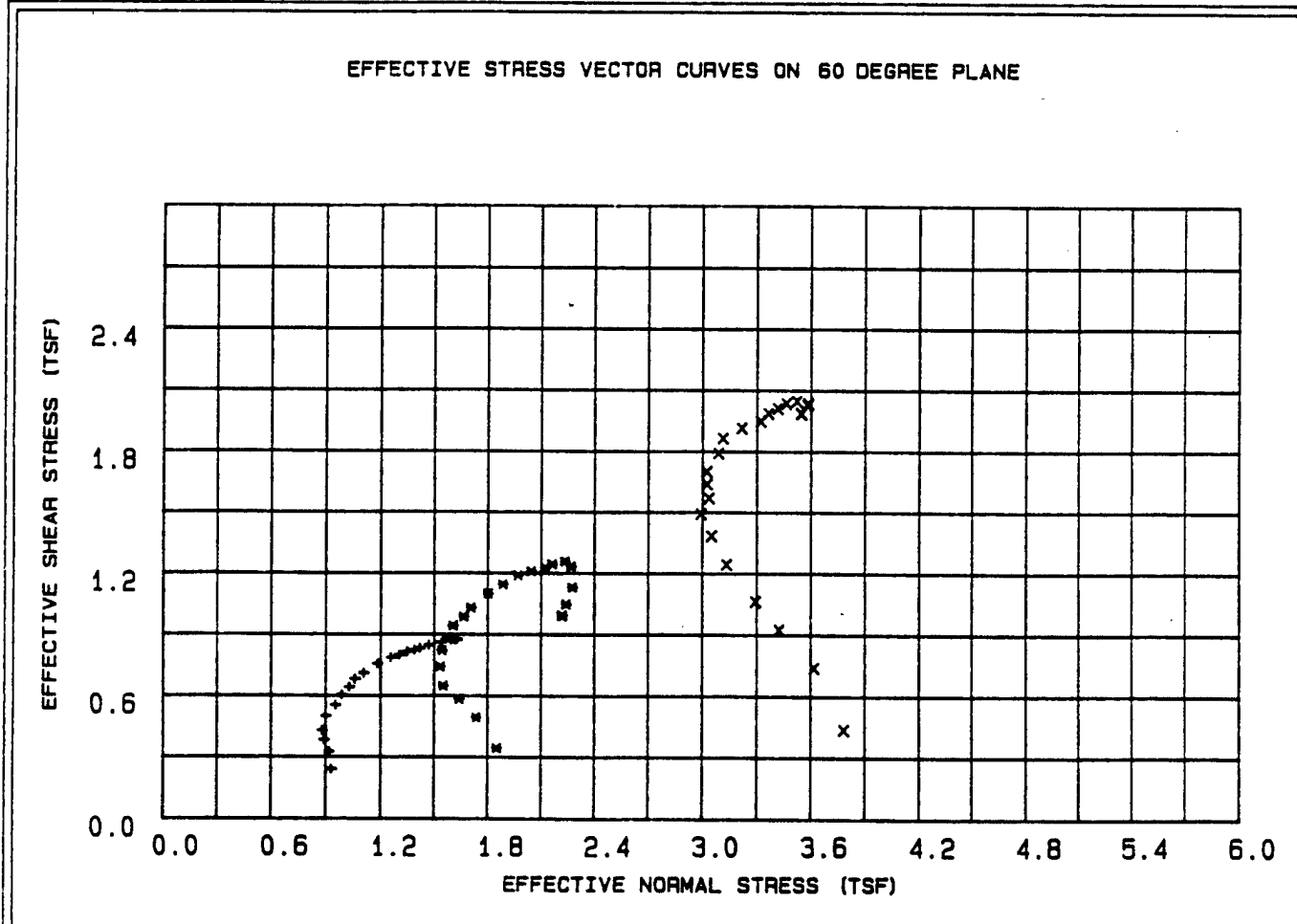
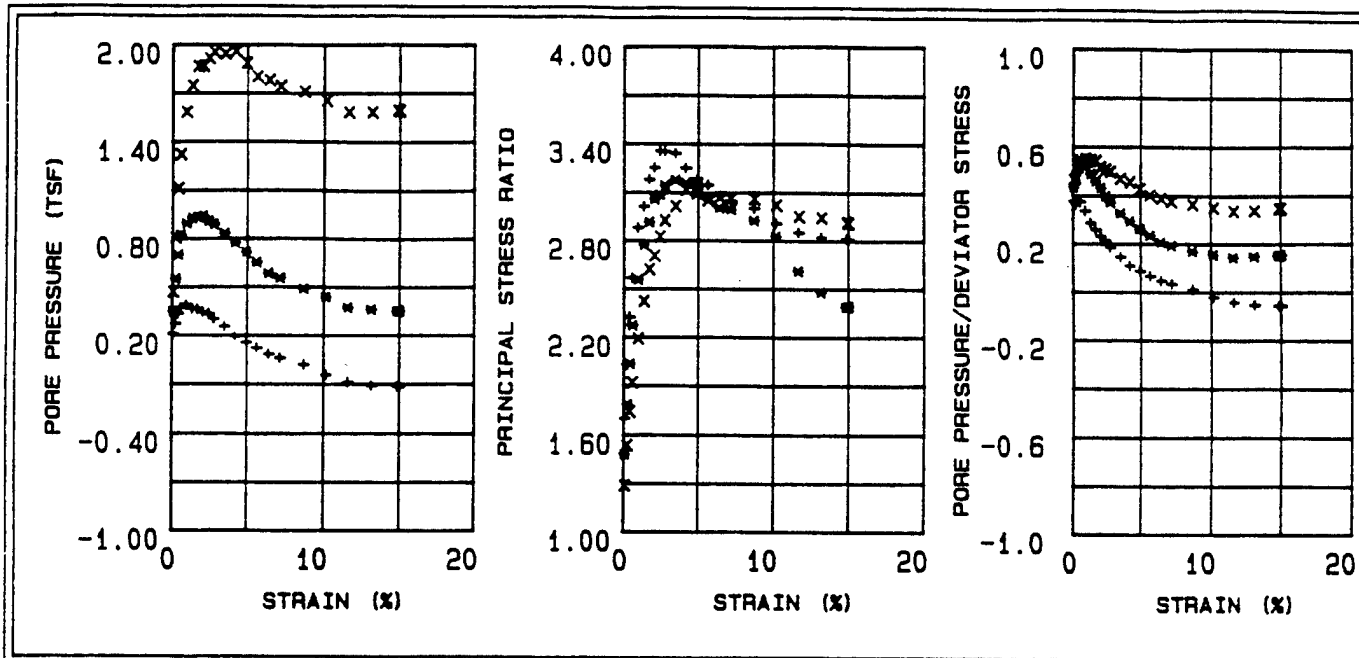
Calcareous.

BORING NO 89-112 MU SAMPLE NO. S-5

DEPTH FLEV 42'-44'

LABORATORY 90/135 DATE

TRIAXIAL COMPRESSION TEST REPORT



LEGEND  
 + = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF

PROJECT MINNESOTA RIVER; IA-90-04-ED-GH  
 BORING NO. 89-112 MU  
 SAMPLE NO. S-5  
 DEPTH/ELEV 42'-44'  
 MRD LAB NO. 90/135

FIGURE 15

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-5  
 Depth : 42'-44'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.553	0.207	1.698	0.375	0.930	0.239
30	0.24	0.750	0.270	2.028	0.361	0.916	0.324
45	0.41	0.883	0.332	2.323	0.377	0.887	0.381
60	0.58	0.989	0.368	2.565	0.373	0.877	0.427
90	0.94	1.153	0.386	2.877	0.335	0.899	0.498
120	1.33	1.279	0.364	3.010	0.285	0.953	0.552
150	1.69	1.396	0.359	3.177	0.257	0.987	0.603
180	2.05	1.486	0.340	3.251	0.229	1.028	0.641
210	2.42	1.575	0.331	3.355	0.211	1.059	0.680
240	2.76	1.646	0.300	3.352	0.183	1.107	0.710
300	3.48	1.750	0.252	3.339	0.144	1.181	0.755
360	4.18	1.818	0.192	3.250	0.106	1.258	0.784
420	4.93	1.848	0.154	3.184	0.084	1.304	0.798
480	5.66	1.887	0.120	3.146	0.064	1.347	0.815
540	6.43	1.907	0.083	3.080	0.044	1.389	0.823
600	7.18	1.927	0.058	3.046	0.031	1.419	0.832
720	8.71	1.964	0.017	2.999	0.009	1.469	0.848
840	10.16	1.993	-0.047	2.903	-0.023	1.540	0.860
960	11.63	2.018	-0.092	2.848	-0.045	1.592	0.871
1080	13.16	2.024	-0.113	2.819	-0.055	1.614	0.874
1200	14.85	2.022	-0.118	2.809	-0.058	1.619	0.873
1211	15.00	2.023	-0.121	2.805	-0.059	1.622	0.873
1211	15.00	2.023	-0.121	2.805	-0.059	1.622	0.873

Table 5 - Triaxial R Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-5  
 Depth : 42'-44'  
 Confining Pressure : 2 TSF

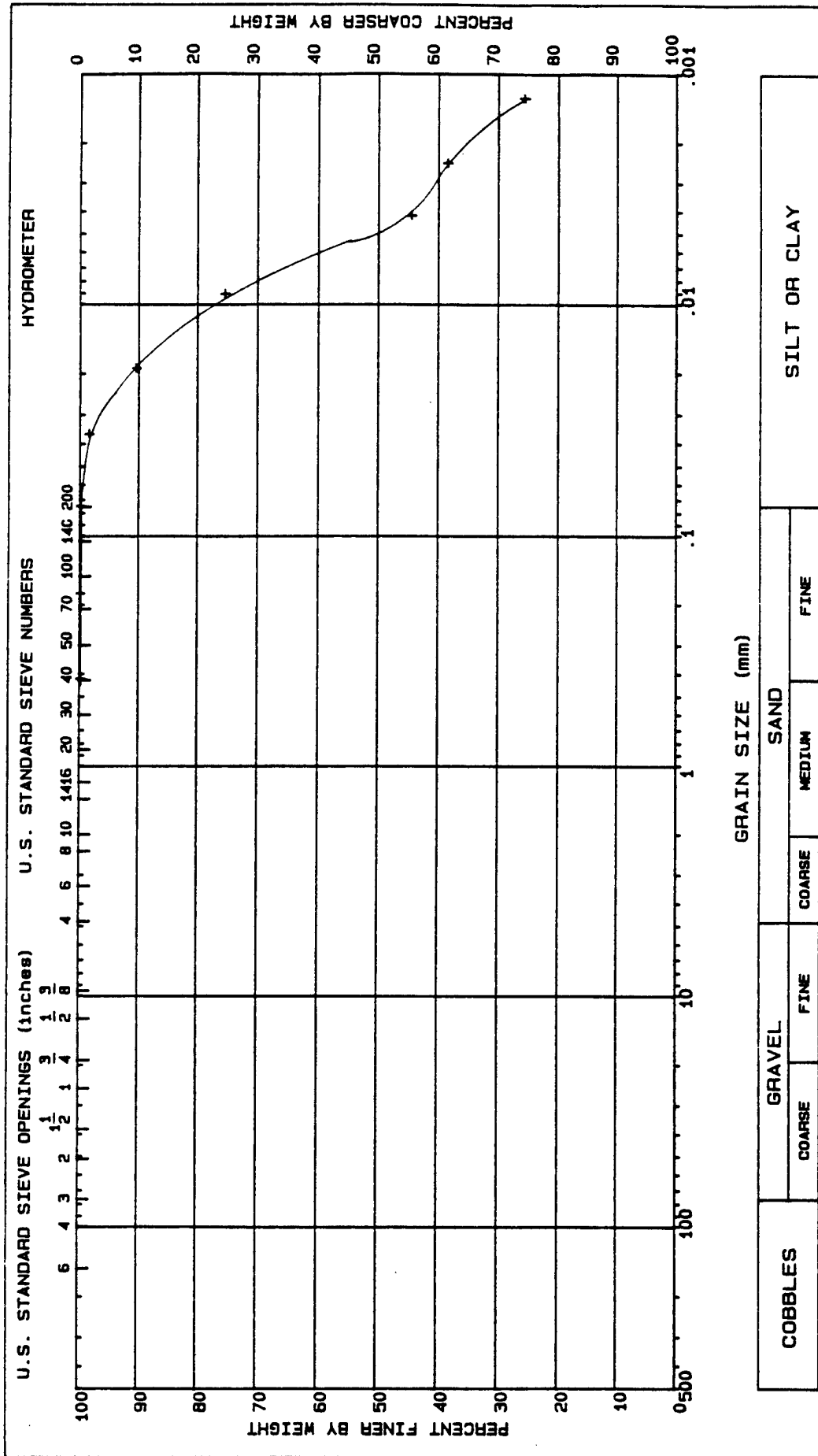
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.795	0.345	1.480	0.434	1.852	0.343
30	0.24	1.140	0.548	1.785	0.482	1.734	0.492
45	0.41	1.348	0.698	2.035	0.518	1.636	0.582
60	0.58	1.499	0.821	2.271	0.549	1.550	0.647
90	0.94	1.720	0.893	2.554	0.520	1.533	0.742
120	1.33	1.901	0.927	2.771	0.488	1.544	0.820
150	1.69	2.043	0.933	2.914	0.457	1.573	0.882
180	2.05	2.184	0.938	3.056	0.430	1.603	0.942
210	2.41	2.285	0.904	3.085	0.396	1.662	0.986
240	2.75	2.387	0.886	3.142	0.371	1.705	1.030
300	3.48	2.550	0.829	3.177	0.325	1.802	1.100
360	4.18	2.654	0.770	3.159	0.291	1.887	1.146
420	4.93	2.756	0.712	3.140	0.259	1.970	1.189
480	5.65	2.801	0.648	3.071	0.232	2.045	1.209
540	6.42	2.843	0.580	3.002	0.204	2.124	1.227
600	7.17	2.885	0.551	2.991	0.191	2.163	1.245
720	8.69	<del>2.911</del>	<del>0.485</del>	2.922	0.167	2.236	1.257
840	10.14	2.851	0.436	2.822	0.153	2.270	1.231
960	11.61	2.619	0.371	2.608	0.142	2.277	1.130
1080	13.13	2.424	0.358	2.476	0.148	2.242	1.046
1200	14.82	2.294	0.346	2.387	0.151	2.222	0.990
1212	15.00	2.293	0.349	2.389	0.153	2.218	0.990
1212	15.00	2.293	0.349	2.389	0.153	2.218	0.990

Table 6 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-112 MU  
 Sample Number : S-5  
 Depth : 42'-44'  
 Confining Pressure : 4 TSF

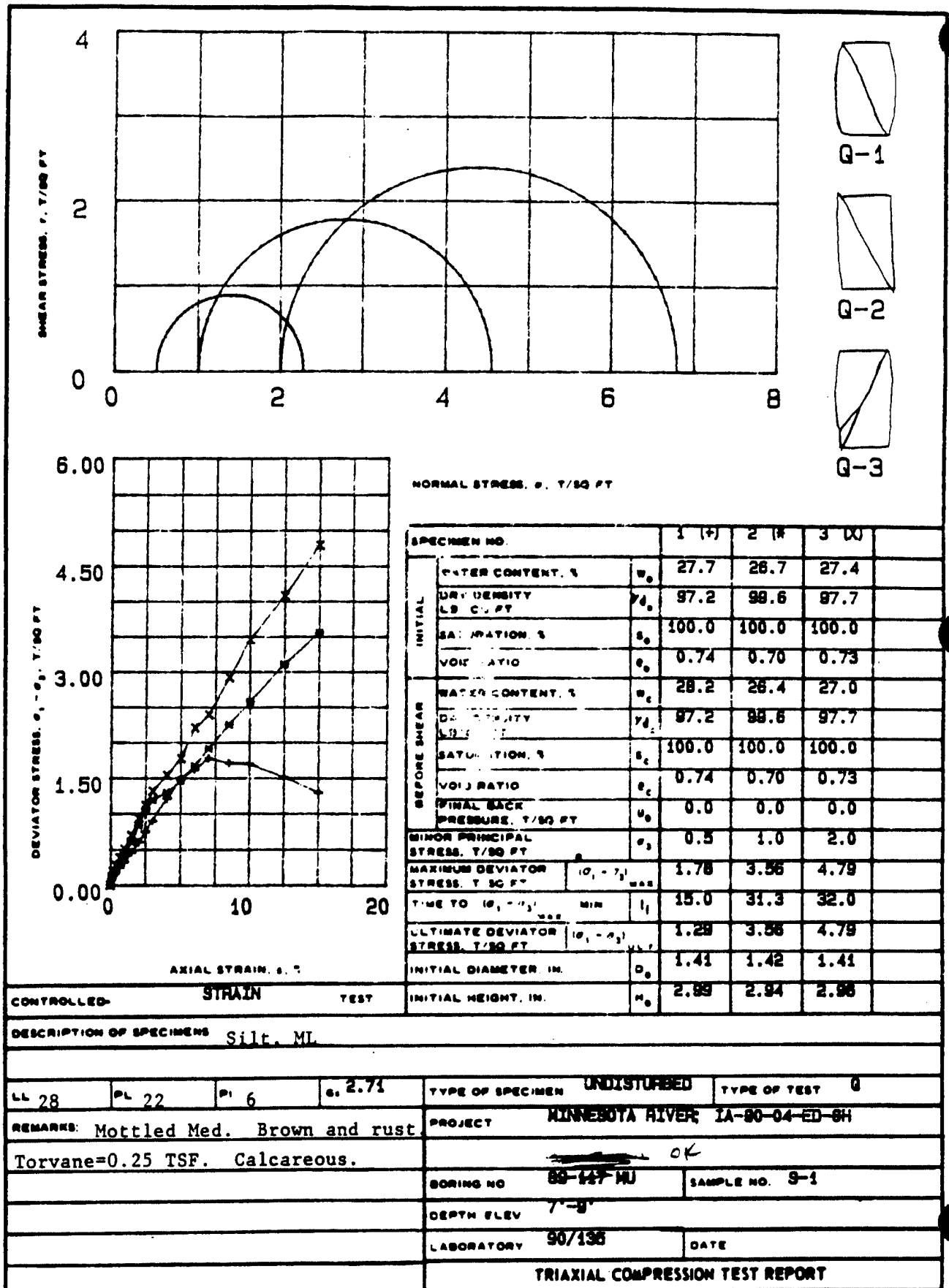
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	1.008	0.467	1.285	0.464	3.783	0.435
30	0.24	1.711	0.806	1.536	0.471	3.618	0.738
45	0.41	2.141	1.110	1.741	0.519	3.420	0.924
60	0.58	2.460	1.319	1.918	0.537	3.290	1.062
90	0.95	2.879	1.582	2.191	0.550	3.131	1.243
120	1.33	3.205	1.745	2.421	0.545	3.048	1.383
150	1.70	3.457	1.866	2.620	0.540	2.990	1.492
180	2.06	3.636	1.866	2.704	0.514	3.034	1.570
210	2.42	3.797	1.916	2.822	0.505	3.024	1.639
240	2.76	3.939	1.953	2.925	0.496	3.022	1.700
300	3.49	4.148	1.941	3.014	0.468	3.086	1.790
360	4.20	4.320	1.958	3.115	0.454	3.111	1.864
420	4.95	4.434	1.883	3.094	0.425	3.215	1.914
480	5.67	4.513	1.799	3.050	0.399	3.318	1.948
540	6.45	4.604	1.778	3.072	0.387	3.362	1.987
600	7.20	4.660	1.741	3.063	0.374	3.413	2.011
720	8.73	4.718	1.707	3.058	0.362	3.461	2.036
840	10.19	4.742	1.653	3.020	0.349	3.521	2.047
960	11.67	4.713	1.582	2.949	0.336	3.585	2.034
1080	13.19	4.695	1.582	2.942	0.337	3.580	2.027
1200	14.89	4.602	1.594	2.913	0.347	3.545	1.986
1208	15.00	4.598	1.592	2.909	0.347	3.546	1.984
1208	15.00	4.598	1.592	2.909	0.347	3.546	1.984

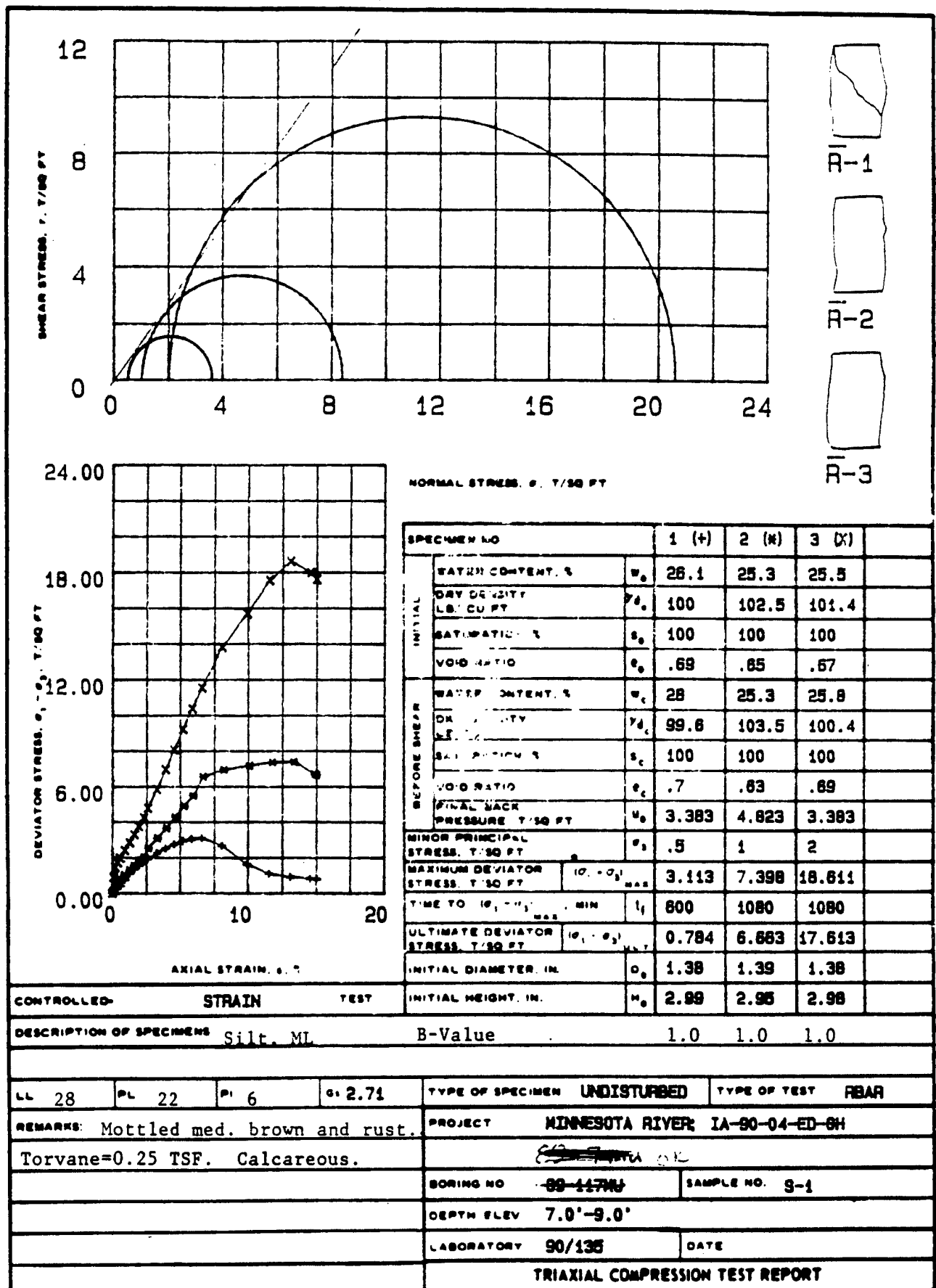


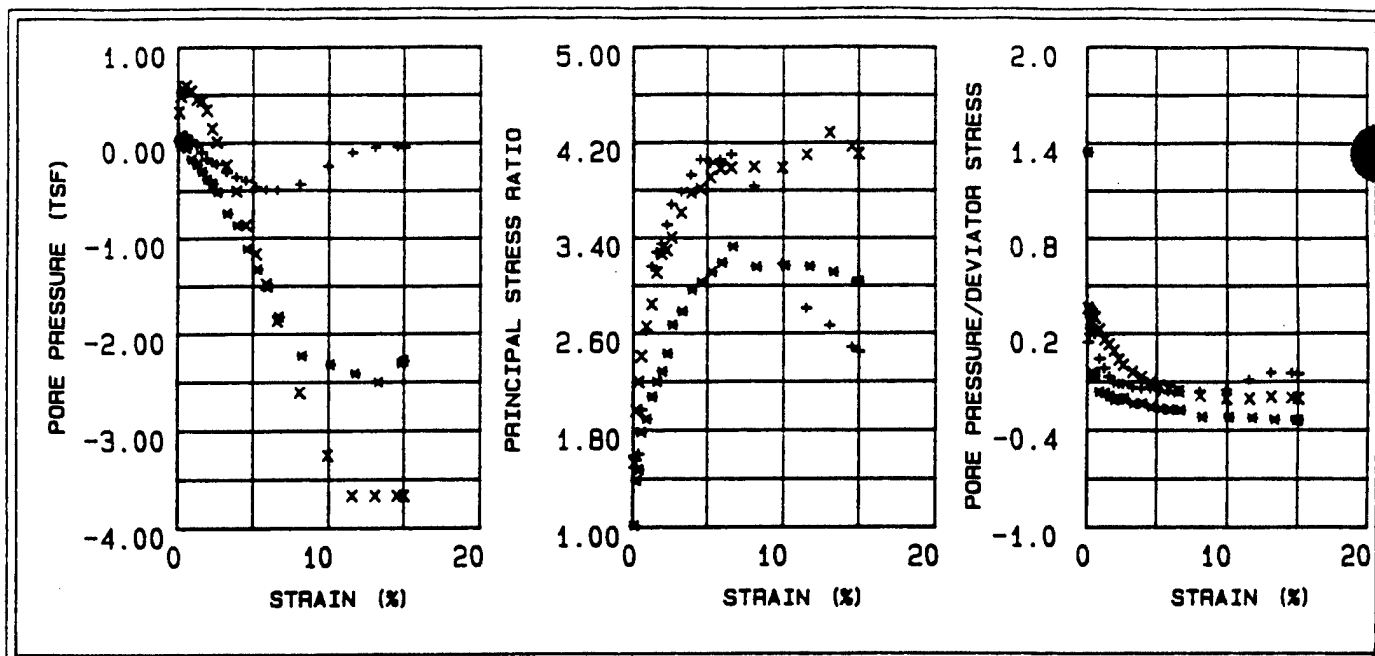


LL - 38	PL - 17	PI - 21	Gs - 2.73	NAT W -	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
CLASSIFICATION Lean clay, CL						BORING NO.	89-112 MU
						SAMPLE NO.	S-5
						DEPTH/ELEV	42'-44'
GRADATION CURVE						MRD LAB NO.	90/135

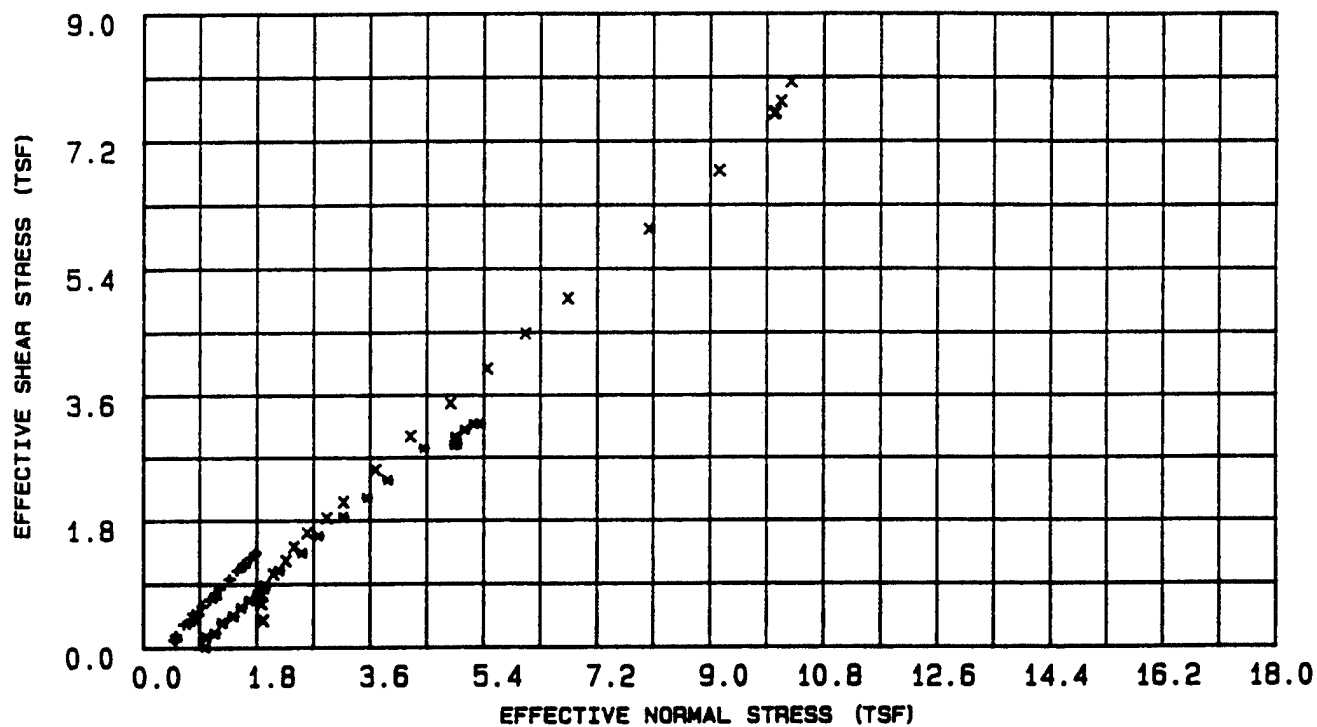
FIGURE 16







### EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



#### LEGEND

+ = .5 TSF  
 \* = 1 TSF  
 x = 2 TSF

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

#### BORING NO.

~~89-117MU~~ OK

#### SAMPLE NO.

S-1

#### DEPTH/ELEV

7.0'-9.0'

#### MRO LAB NO.

90/135

FIGURE 3

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : ~~89-117MU~~ ~~89-7mu~~ ~~OK~~  
 Sample Number : S-1  
 Depth : 7.0'-9.0'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.271	0.039	1.587	0.146	0.528	0.117
30	0.21	0.251	0.049	1.557	0.198	0.513	0.108
45	0.38	0.258	0.073	1.604	0.283	0.491	0.111
60	0.57	0.408	0.079	1.968	0.193	0.522	0.176
90	0.90	0.761	0.031	2.621	0.041	0.657	0.328
120	1.26	1.120	-0.019	3.158	-0.016	0.796	0.483
150	1.59	1.361	-0.098	3.278	-0.071	0.935	0.587
180	1.92	1.574	-0.170	3.348	-0.108	1.060	0.679
210	2.28	1.767	-0.205	3.506	-0.116	1.143	0.763
240	2.58	1.943	-0.226	3.678	-0.116	1.207	0.839
300	3.25	2.255	-0.310	3.784	-0.137	1.368	0.973
360	3.89	2.528	-0.364	3.926	-0.143	1.490	1.091
420	4.53	2.754	-0.402	4.055	-0.145	1.584	1.189
480	5.19	2.942	-0.472	4.028	-0.160	1.700	1.270
540	5.85	3.051	-0.499	4.053	-0.163	1.754	1.317
600	6.57	3.113	-0.504	4.102	-0.161	1.775	1.343
720	8.06	2.666	-0.441	3.833	-0.165	1.601	1.151
840	9.91	1.626	-0.246	3.180	-0.151	1.149	0.702
960	11.52	1.085	-0.100	2.808	-0.092	0.869	0.468
1080	13.06	0.901	-0.042	2.662	-0.046	0.765	0.389
1200	14.53	0.801	-0.041	2.481	-0.050	0.739	0.346
1240	15.00	0.784	-0.044	2.442	-0.055	0.738	0.338

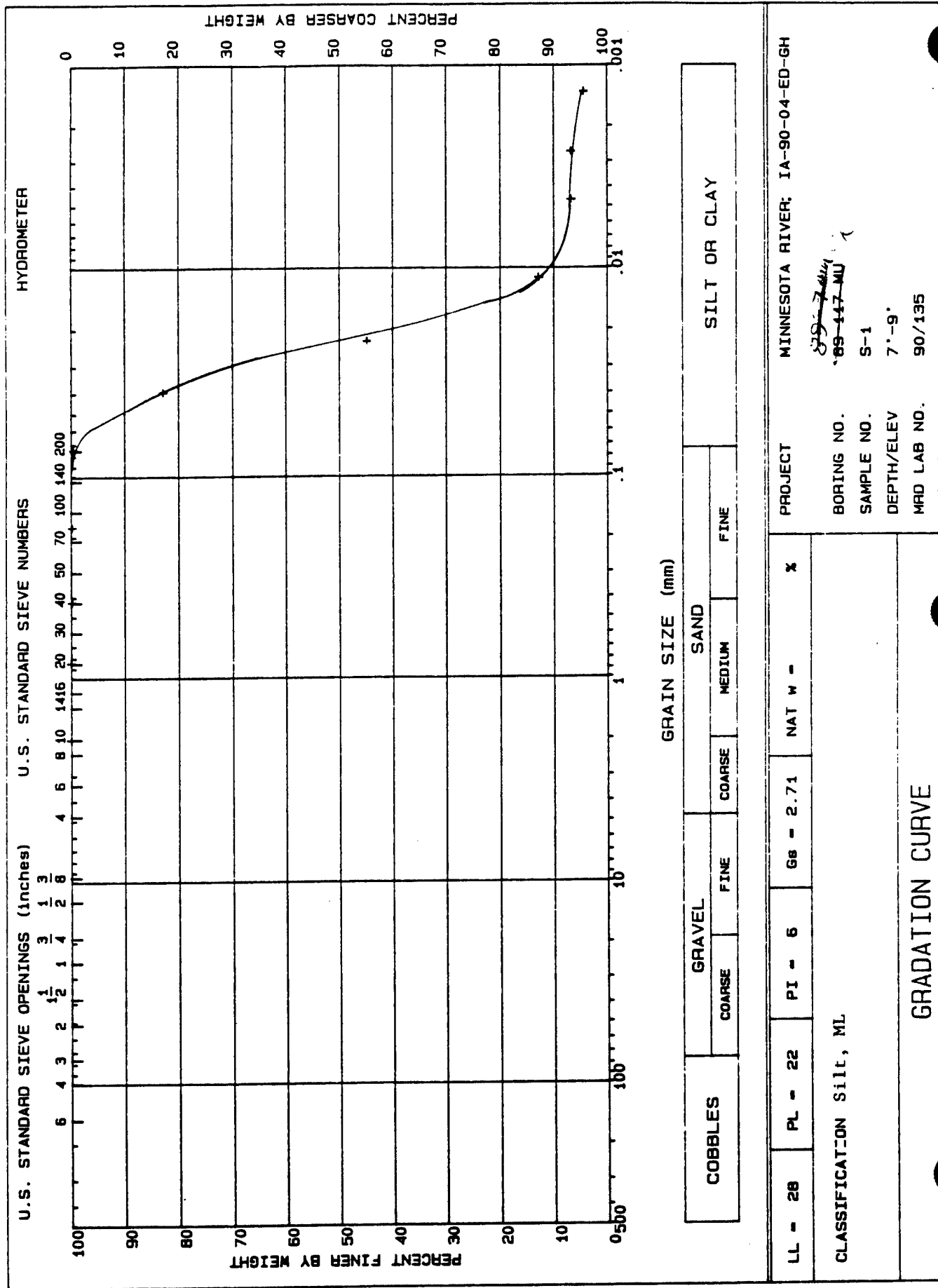
Boring Number : 89-117MU ~~89-77a~~  
Sample Number : S-1



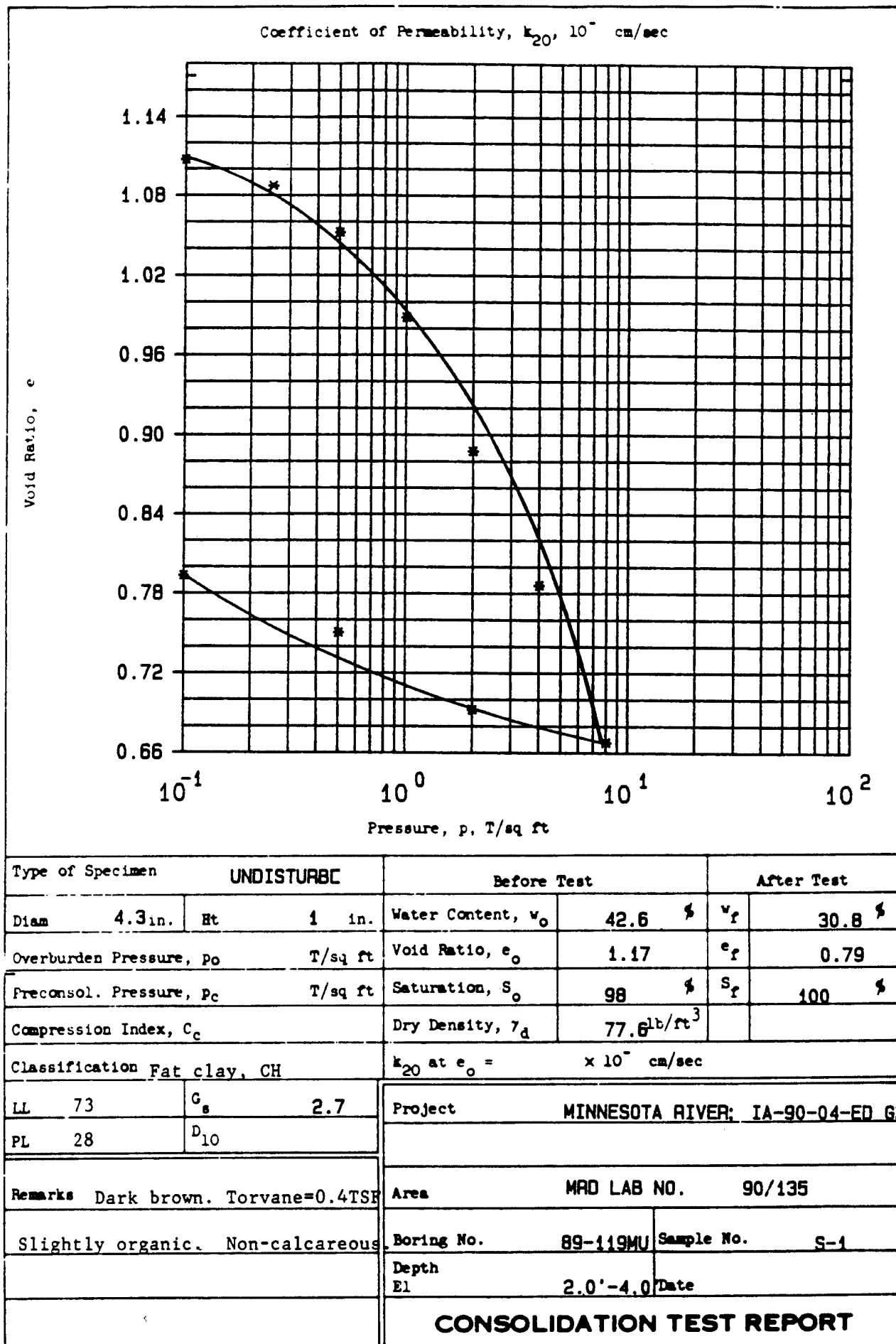
Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : ~~89-117MU~~ ~~89-117MU~~  
 Sample Number : S-1  
 Depth : 7.0'-9.0'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.893	0.321	1.532	0.360	1.900	0.386
30	0.21	1.450	0.487	1.958	0.336	1.872	0.626
45	0.38	1.734	0.551	2.196	0.318	1.878	0.748
60	0.57	1.980	0.593	2.408	0.300	1.897	0.854
90	0.90	2.417	0.538	2.654	0.223	2.060	1.043
120	1.26	2.851	0.451	2.840	0.159	2.255	1.231
150	1.59	3.300	0.433	3.106	0.132	2.384	1.424
180	1.92	3.764	0.337	3.263	0.090	2.595	1.625
210	2.28	4.259	0.146	3.297	0.035	2.908	1.838
240	2.59	4.788	0.007	3.402	0.002	3.178	2.066
300	3.25	5.849	-0.241	3.610	-0.041	3.689	2.524
360	3.90	6.967	-0.510	3.776	-0.073	4.235	3.007
420	4.54	8.069	-0.870	3.812	-0.107	4.868	3.483
480	5.20	9.222	-1.173	3.907	-0.127	5.456	3.980
540	5.87	10.392	-1.486	3.981	-0.143	6.059	4.485
600	6.58	11.555	-1.868	3.987	-0.161	6.729	4.987
720	8.08	13.811	-2.609	3.997	-0.188	8.028	5.961
840	9.93	15.710	-3.256	3.989	-0.207	9.145	6.781
960	11.55	17.568	-3.670	4.099	-0.208	10.019	7.583
1080	13.09	18.611	-3.670	4.283	-0.197	10.278	8.033
1200	14.56	17.971	-3.670	4.170	-0.204	10.119	7.756
1237	15.00	17.613	-3.670	4.107	-0.208	10.031	7.602







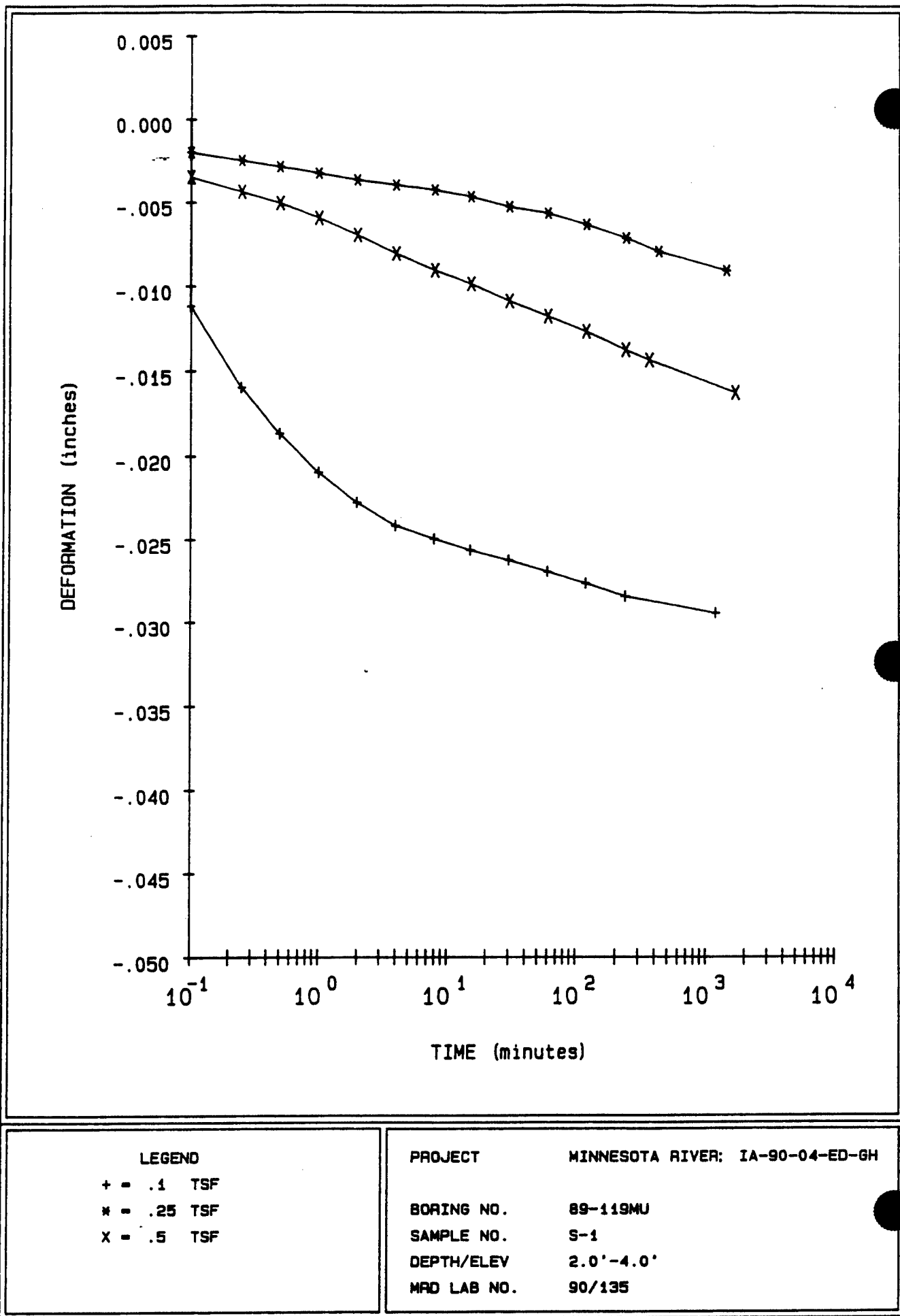
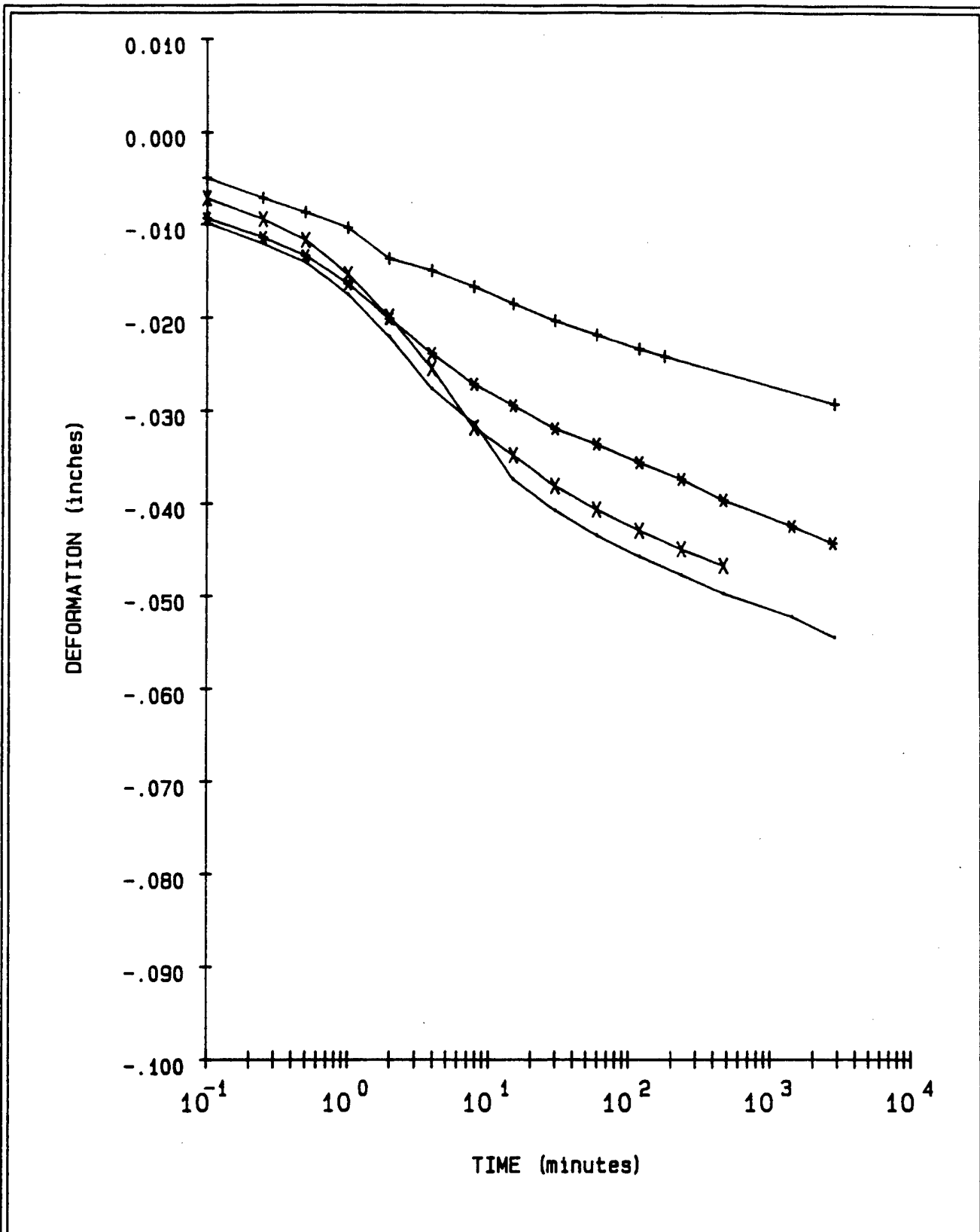


FIGURE 18



<b>LEGEND</b>		<b>PROJECT</b>	MINNESOTA RIVER; IA-90-04-ED-GH
+	1 TSF	<b>BORING NO.</b>	89-119MU
*	2 TSF	<b>SAMPLE NO.</b>	S-1
X	4 TSF	<b>DEPTH/ELEV</b>	2.0'-4.0'
-	8 TSF	<b>MRD LAB NO.</b>	90/135

FIGURE 19

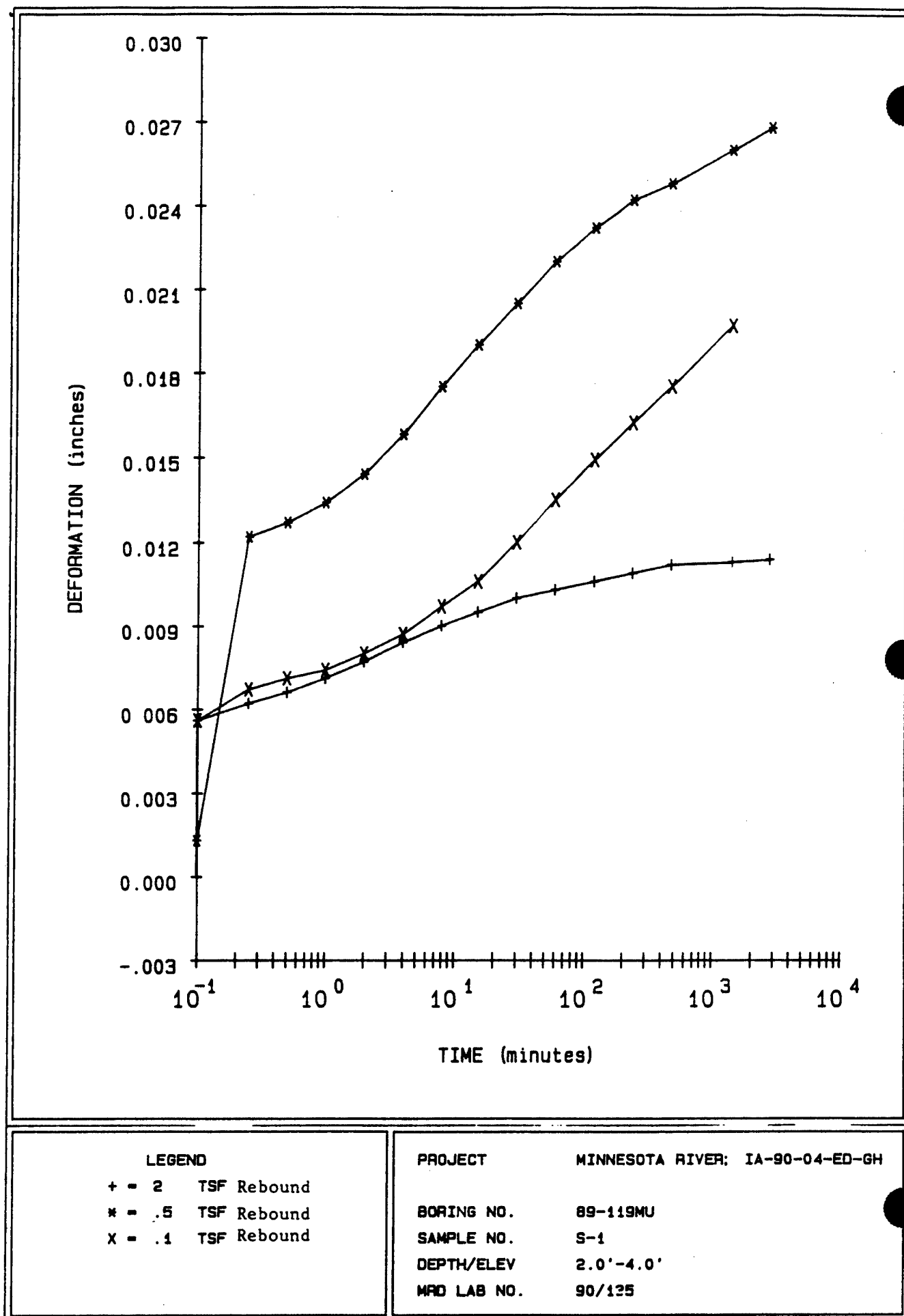


FIGURE 20

# Consolidation Test Data

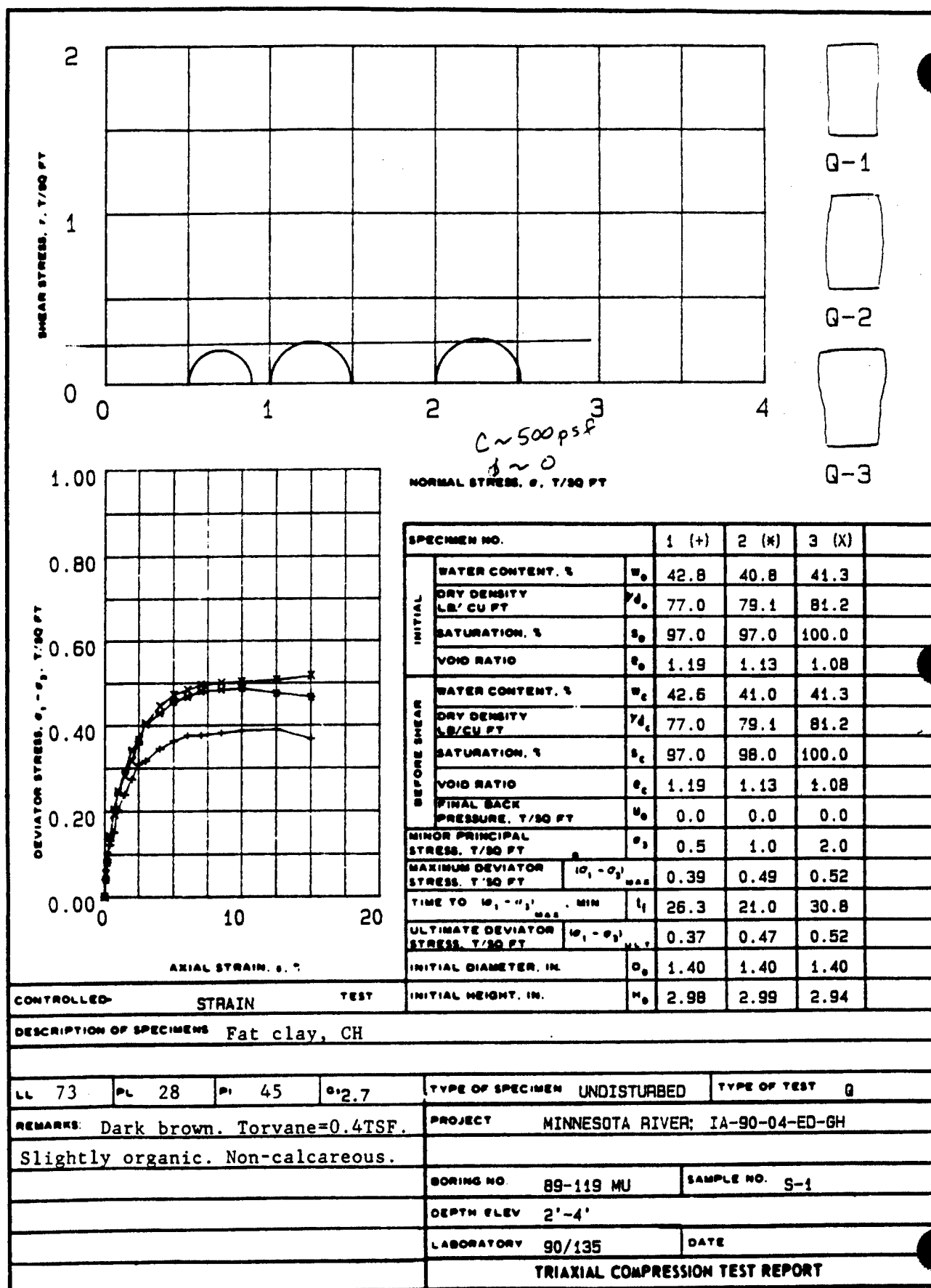
Project MINNESOTA RIVER; IA-90-04-ED-GH

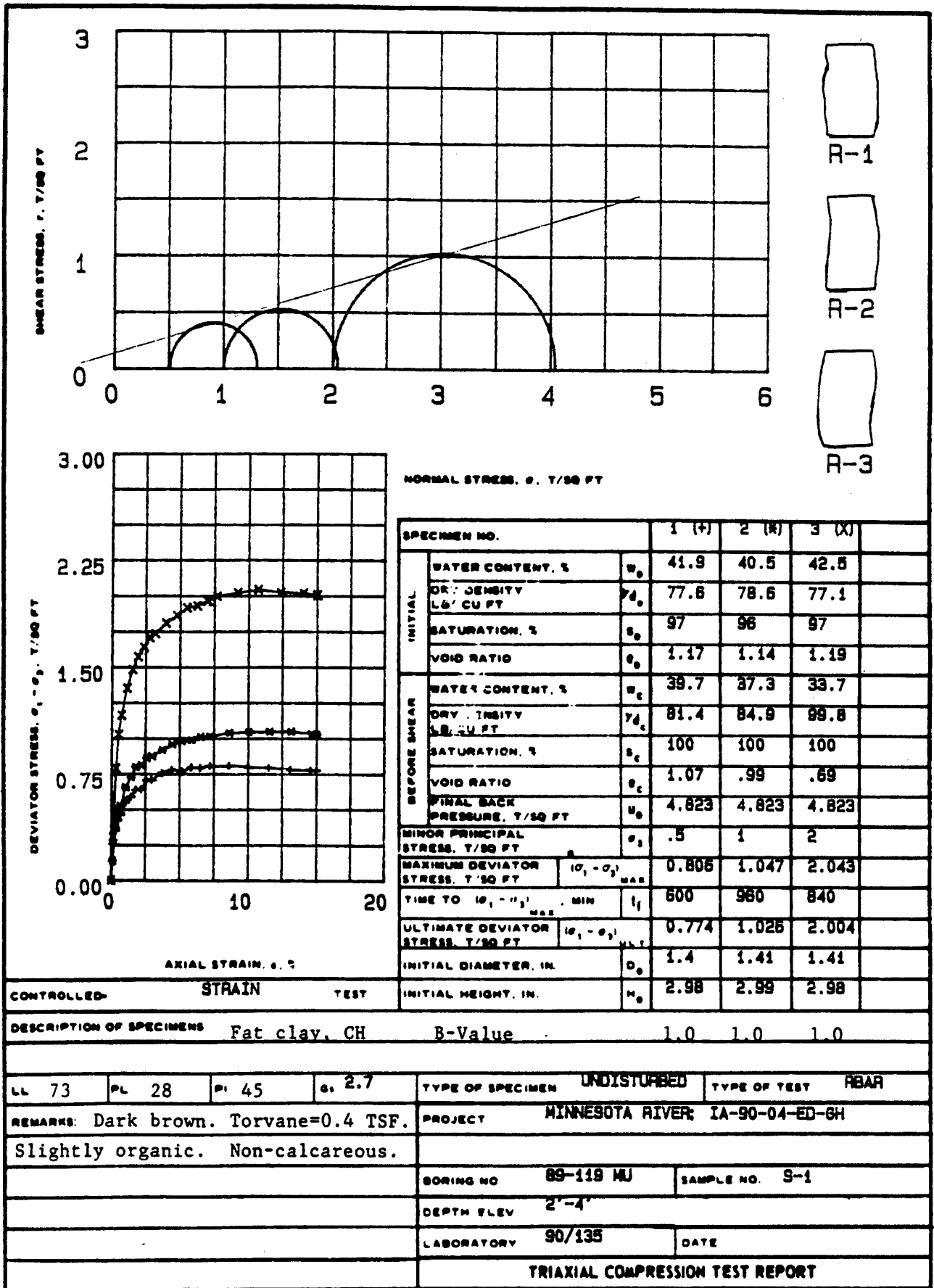
Boring No. 89-119MU  
Sample No. S-1  
Depth/Elev 2.0'-4.0'  
MRD Lab No. 90/135

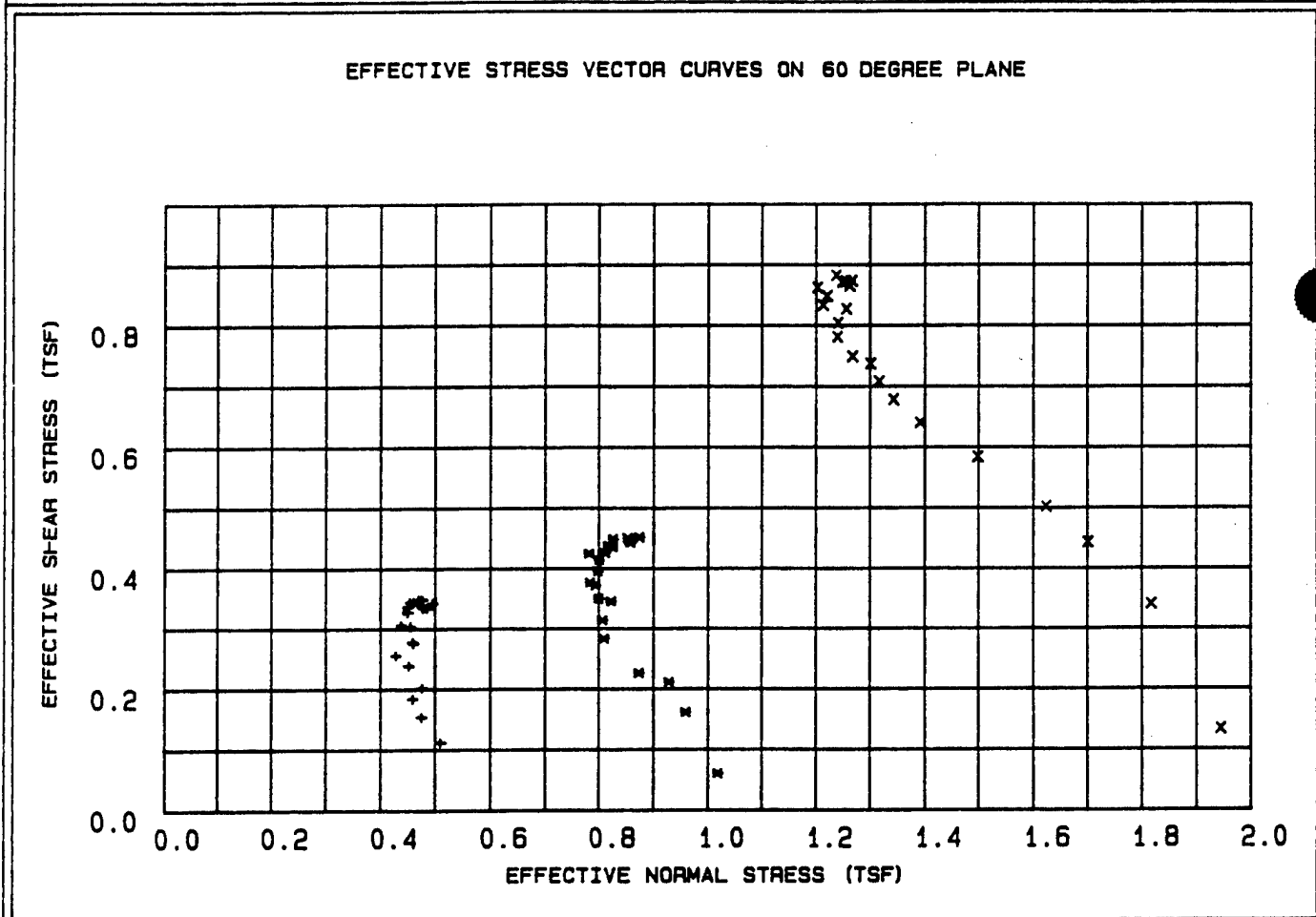
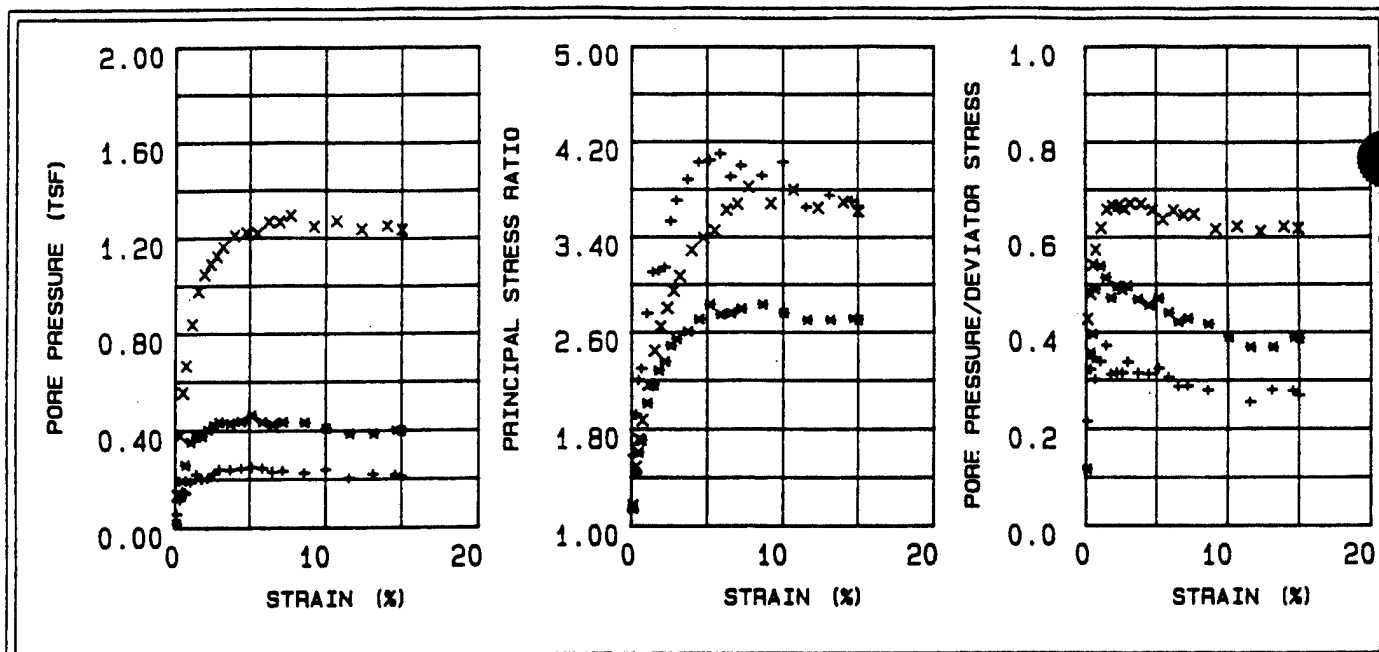
Gs = 2.7  
eo = 1.171  
0.42eo = 0.492

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
42.6	291.7	77.6	1.171		98.2
41.1	291.7	80.0	1.107	0.10	100.0
41.1	291.7	80.7	1.087	0.25	100.0
41.1	291.7	82.1	1.052	0.50	100.0
41.1	291.7	84.7	0.988	1.00	100.0
41.1	291.7	89.1	0.892	2.00	100.0
41.1	291.7	94.1	0.790	4.00	100.0
41.1	291.7	100.8	0.672	8.00	100.0
1.1	291.7	99.3	0.697	2.00	100.0
41.1	291.7	96.0	0.755	0.50	100.0
41.1	291.7	93.7	0.798	0.10	100.0

Axial Strain (%)	Void Ratio
1	1.149
2	1.127
3	1.106
4	1.084
5	1.062
6	1.041
7	1.019
8	0.997
9	0.975
10	0.954
11	0.932
12	0.910
13	0.889
14	0.867
15	0.845
16	0.824
17	0.802
18	0.780
19	0.758
20	0.737







<p>LEGEND</p> <p>+ = .5 TSF</p> <p>* = 1 TSF</p> <p>x = 2 TSF</p>		<p>PROJECT MINNESOTA RIVER; IA-90-04-ED-GH</p>	
<p>BORING NO. 89-119 MU</p>			
<p>SAMPLE NO. S-1</p>			
<p>DEPTH/ELEV 2'-4'</p>			
<p>MRO LAB NO. 90/135</p>			

FIGURE 23



Table 7 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-1  
 Depth : 2'-4'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.258	0.055	1.579	0.215	0.509	0.111
30	0.34	0.354	0.114	1.918	0.322	0.474	0.153
45	0.51	0.424	0.147	2.202	0.346	0.458	0.183
60	0.71	0.467	0.140	2.298	0.301	0.476	0.201
90	1.07	0.552	0.186	2.757	0.338	0.451	0.238
120	1.46	0.590	0.219	3.102	0.372	0.427	0.255
150	1.82	0.638	0.198	3.112	0.311	0.460	0.275
180	2.21	0.641	0.201	3.144	0.314	0.458	0.277
210	2.60	0.705	0.221	3.531	0.314	0.454	0.304
240	2.97	0.708	0.238	3.706	0.337	0.437	0.306
300	3.70	0.757	0.237	3.881	0.314	0.450	0.327
360	4.43	0.779	0.243	4.026	0.312	0.450	0.336
420	5.13	0.767	0.248	4.041	0.324	0.442	0.331
	5.84	0.797	0.243	4.096	0.305	0.454	0.344
540	6.52	0.793	0.227	3.901	0.286	0.469	0.342
600	7.20	0.806	0.231	3.995	0.287	0.469	0.348
720	8.59	0.806	0.223	3.913	0.278	0.476	0.348
840	10.00	0.796	0.237	4.029	0.299	0.460	0.344
960	11.53	0.792	0.201	3.648	0.254	0.495	0.342
1080	13.08	0.778	0.217	3.750	0.279	0.476	0.336
1200	14.57	0.774	0.214	3.703	0.277	0.478	0.334
1232	15.00	0.774	0.207	3.643	0.268	0.485	0.334

Table 8 - Triaxial  $\bar{R}$  Test Results

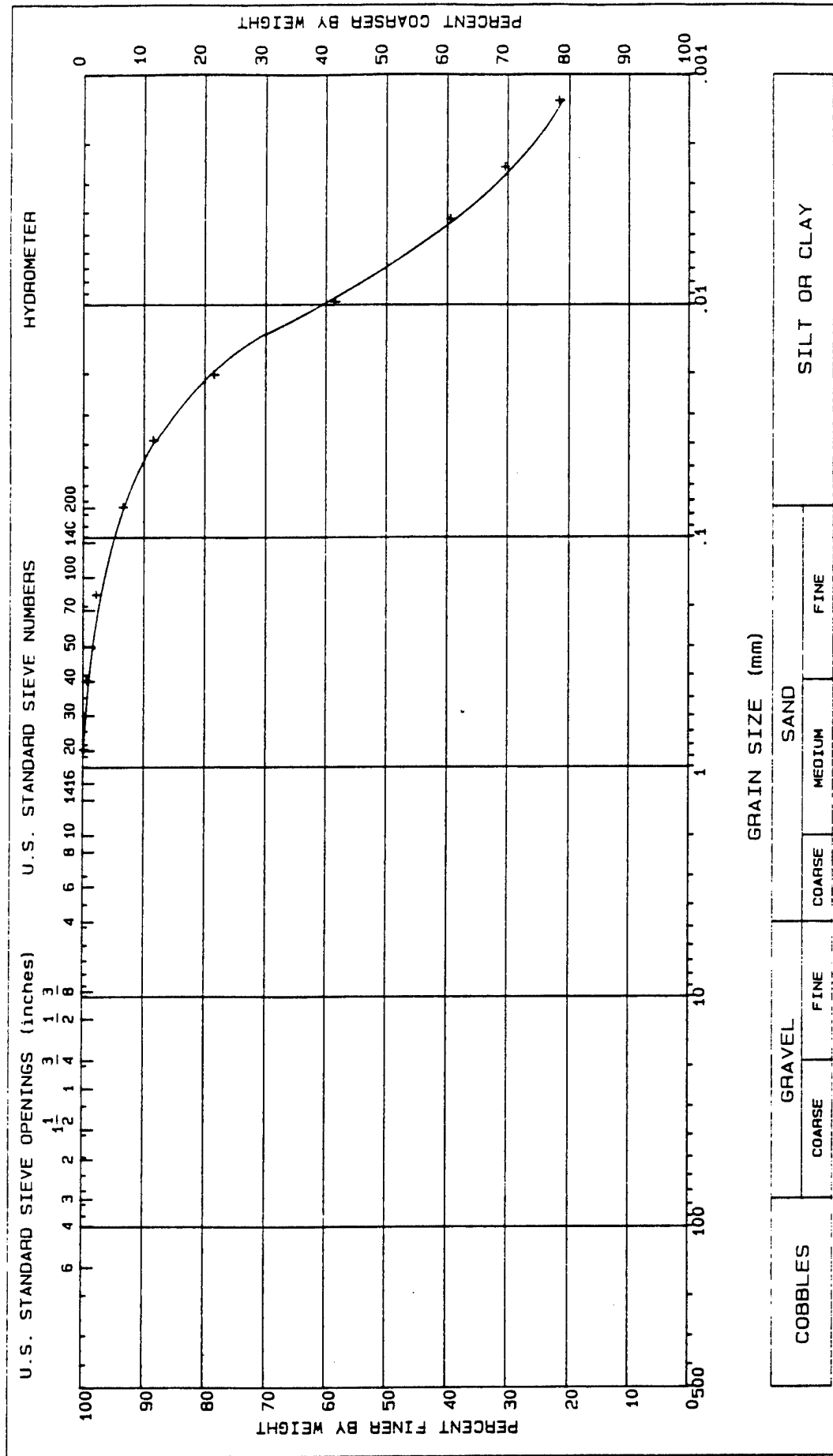
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-1  
 Depth : 2'-4'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.138	0.016	1.141	0.116	1.018	0.060
30	0.34	0.372	0.133	1.430	0.357	0.959	0.161
45	0.51	0.488	0.193	1.605	0.396	0.928	0.211
60	0.71	0.525	0.257	1.706	0.490	0.873	0.226
90	1.08	0.656	0.353	2.013	0.538	0.809	0.283
120	1.47	0.728	0.374	2.162	0.514	0.806	0.314
150	1.83	0.799	0.376	2.280	0.471	0.822	0.345
180	2.23	0.811	0.402	2.358	0.496	0.799	0.350
210	2.62	0.862	0.420	2.487	0.488	0.793	0.372
240	2.98	0.875	0.434	2.546	0.497	0.783	0.377
300	3.72	0.918	0.429	2.607	0.468	0.798	0.396
360	4.45	0.960	0.438	2.708	0.456	0.800	0.414
420	5.16	0.984	0.463	2.830	0.471	0.781	0.425
480	5.87	0.988	0.434	2.746	0.440	0.811	0.426
540	6.56	1.011	0.425	2.759	0.421	0.825	0.436
600	7.24	1.015	0.434	2.794	0.428	0.817	0.438
720	8.64	1.040	0.432	2.833	0.416	0.826	0.449
840	10.05	1.045	0.406	2.759	0.389	0.853	0.451
960	11.59	1.047	0.385	2.701	0.368	0.874	0.452
1080	13.16	<del>1.047</del>	<del>0.385</del>	2.701	0.368	0.874	0.452
1200	14.65	1.031	0.399	2.714	0.387	0.856	0.445
1226	15.00	1.026	0.396	2.700	0.386	0.858	0.443

Table 9 - Triaxial  $\bar{R}$  Test Results

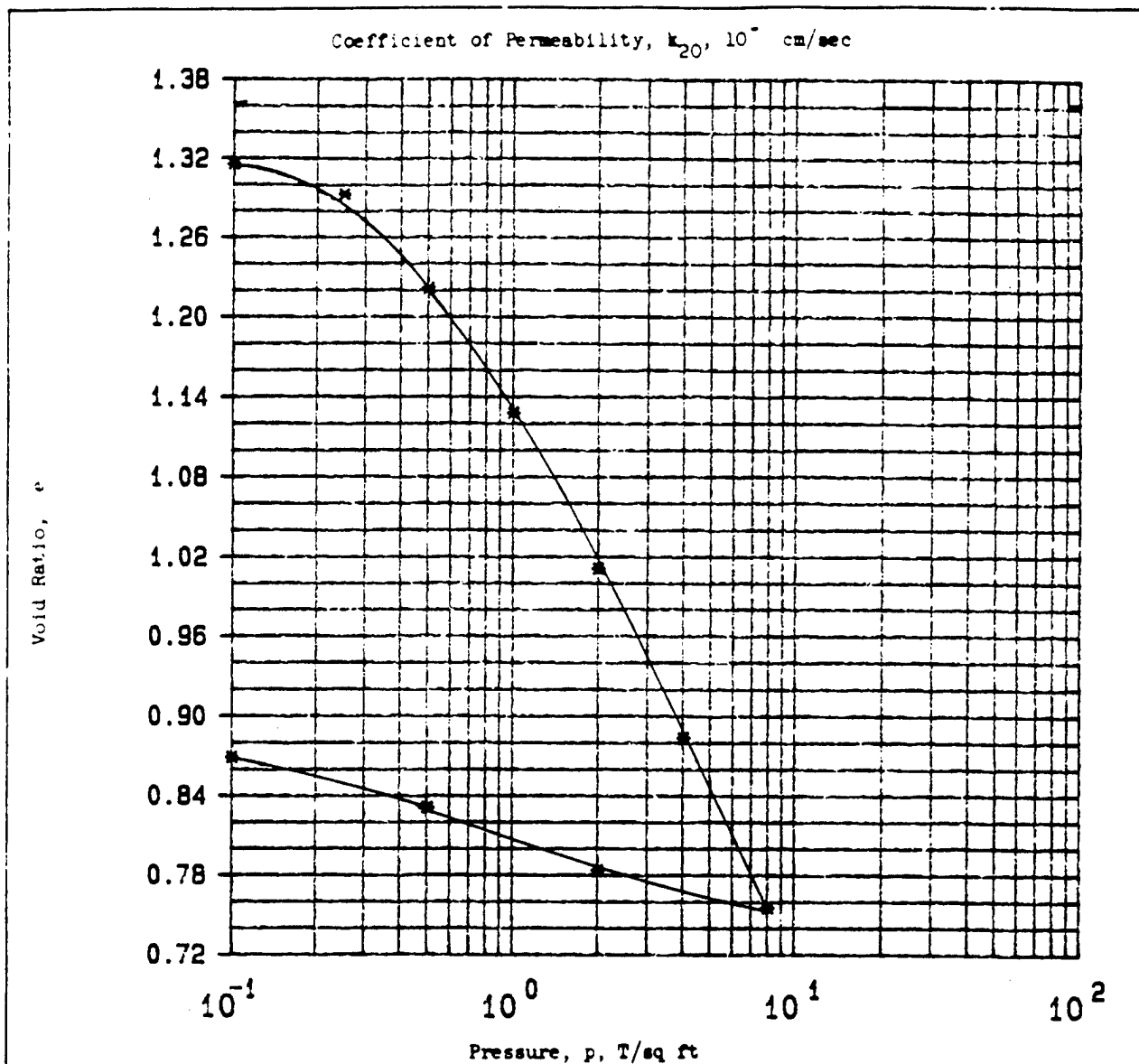
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-1  
 Depth : 2'-4'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.13	0.307	0.131	1.164	0.427	1.945	0.133
30	0.36	0.788	0.378	1.486	0.480	1.817	0.340
45	0.55	1.026	0.554	1.710	0.541	1.700	0.443
60	0.76	1.162	0.665	1.871	0.573	1.623	0.502
90	1.15	1.353	0.837	2.164	0.619	1.498	0.584
120	1.56	1.483	0.976	2.447	0.658	1.391	0.640
150	1.95	1.572	1.046	2.648	0.666	1.343	0.678
180	2.37	1.640	1.090	2.802	0.665	1.316	0.708
210	2.78	1.707	1.123	2.946	0.659	1.300	0.737
240	3.18	1.735	1.162	3.071	0.670	1.267	0.749
300	3.96	1.809	1.209	3.287	0.669	1.239	0.781
360	4.74	1.863	1.221	3.392	0.656	1.240	0.804
420	5.49	1.917	1.218	3.451	0.636	1.256	0.827
480	6.25	1.931	1.265	3.626	0.655	1.213	0.833
540	6.98	1.964	1.266	3.676	0.645	1.220	0.848
	7.70	1.997	1.292	3.819	0.647	1.202	0.862
720	9.19	2.021	1.245	3.678	0.616	1.255	0.872
840	10.70	2.043	1.269	3.795	0.622	1.237	0.882
960	12.34	2.023	1.235	3.642	0.611	1.266	0.873
1080	14.00	2.017	1.251	3.694	0.621	1.248	0.871
1155	15.00	2.004	1.234	3.617	0.617	1.262	0.865
1155	15.00	2.004	1.234	3.617	0.617	1.262	0.865



LL - 73	PL - 28	PI - 45	Gs - 2.7	NAT w -	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
CLASSIFICATION Fat clay, CH						BORING NO.	89-119 MU
						SAMPLE NO.	S-1
						DEPTH/ELEV	2'-4'
						MRD LAB NO.	90/135
GRADATION CURVE							

FIGURE 24



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.4 in.	Ht	1 in.	Water Content, $w_0$	55.3 %	$w_f$	35.7 %
Overburden Pressure, $p_0$		T/sq ft		Void Ratio, $e_0$	1.36	$e_f$	0.87
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_0$	100 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	71.3 lb/ft <sup>3</sup>		
Classification Fat clay, CH				$k_{20}$ at $e_0 =$ $\times 10^{-7}$ cm/sec			
LL	68	$G_s$	2.7	Project MINNESOTA RIVER: IA-90-04-ED-6H			
PL	26	$D_{10}$					
Remarks Dark gray. Torvane=0.15				Area MRD LAB NO. 90/135			
TSF. Slightly calcareous. Slightly				Boring No.	89-119MU	Sample No.	S-3
organic. Numerous shell fragments.				Depth	11'-13'	Date	
				<b>CONSOLIDATION TEST REPORT</b>			

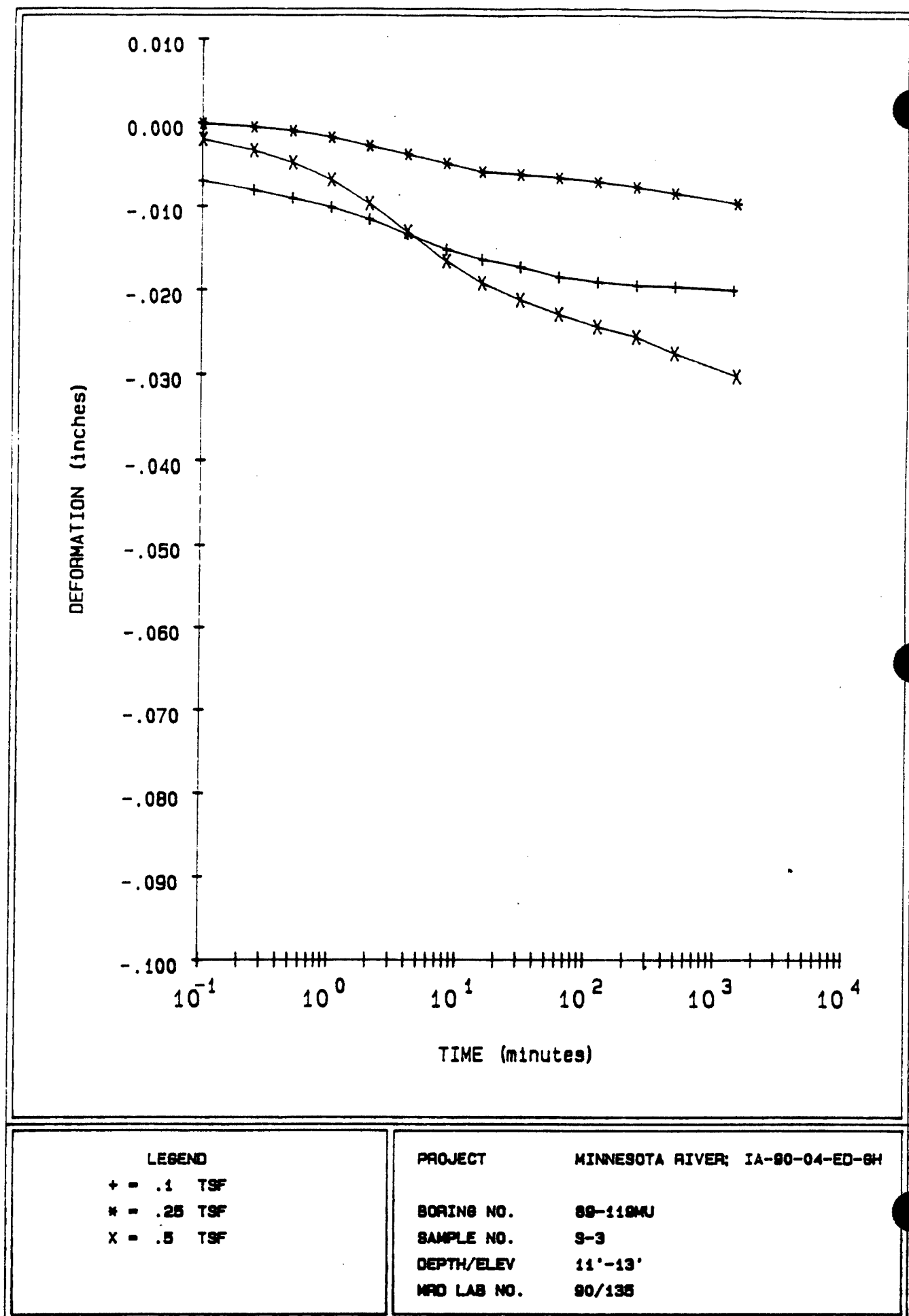
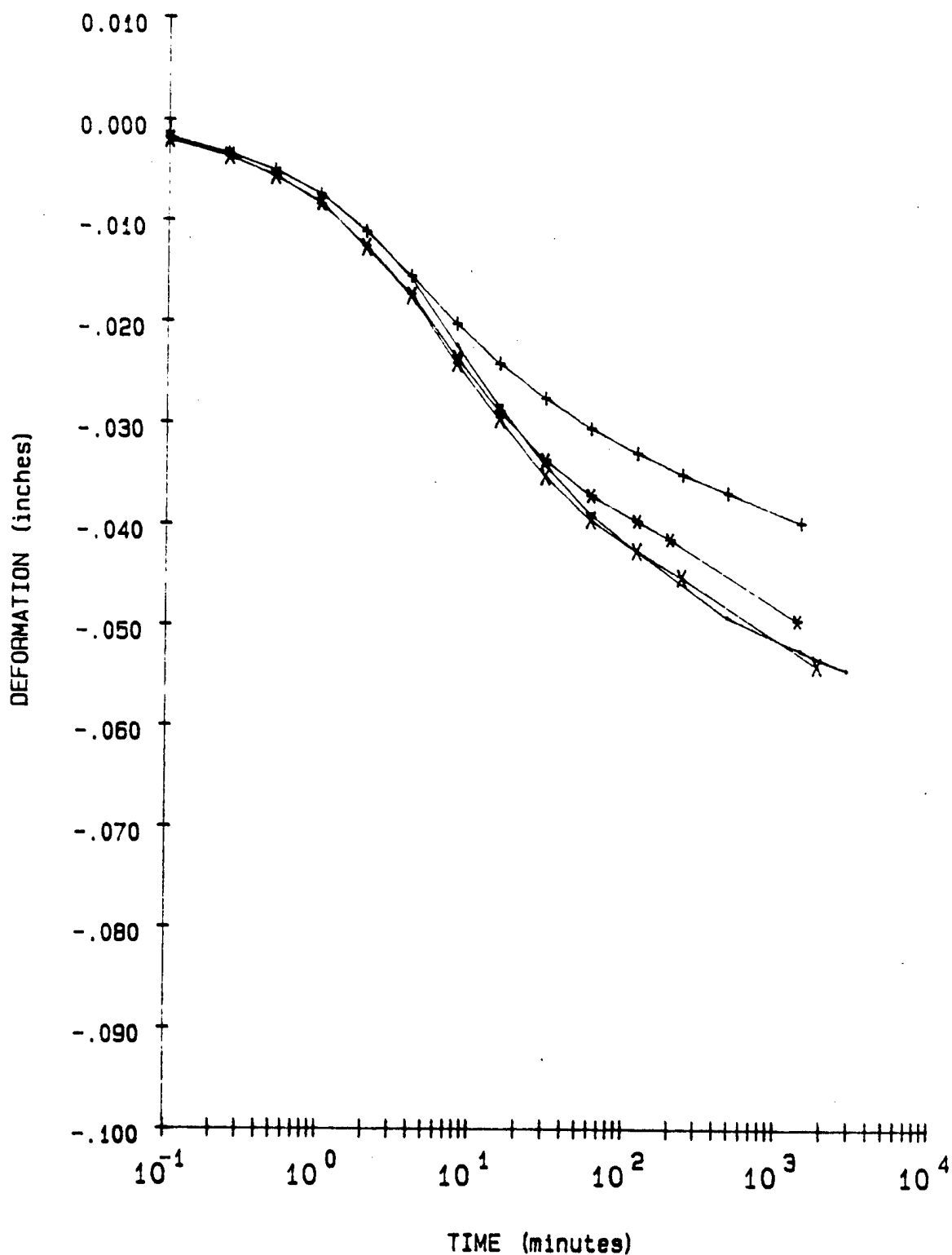


FIGURE 2



#### LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 X = 4 TSF  
 - = 8 TSF

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-6H

#### BORING NO.

89-119MU

#### SAMPLE NO.

9-3

#### DEPTH/ELEV

11'-13'

#### MRD LAB NO.

90/135

FIGURE 3

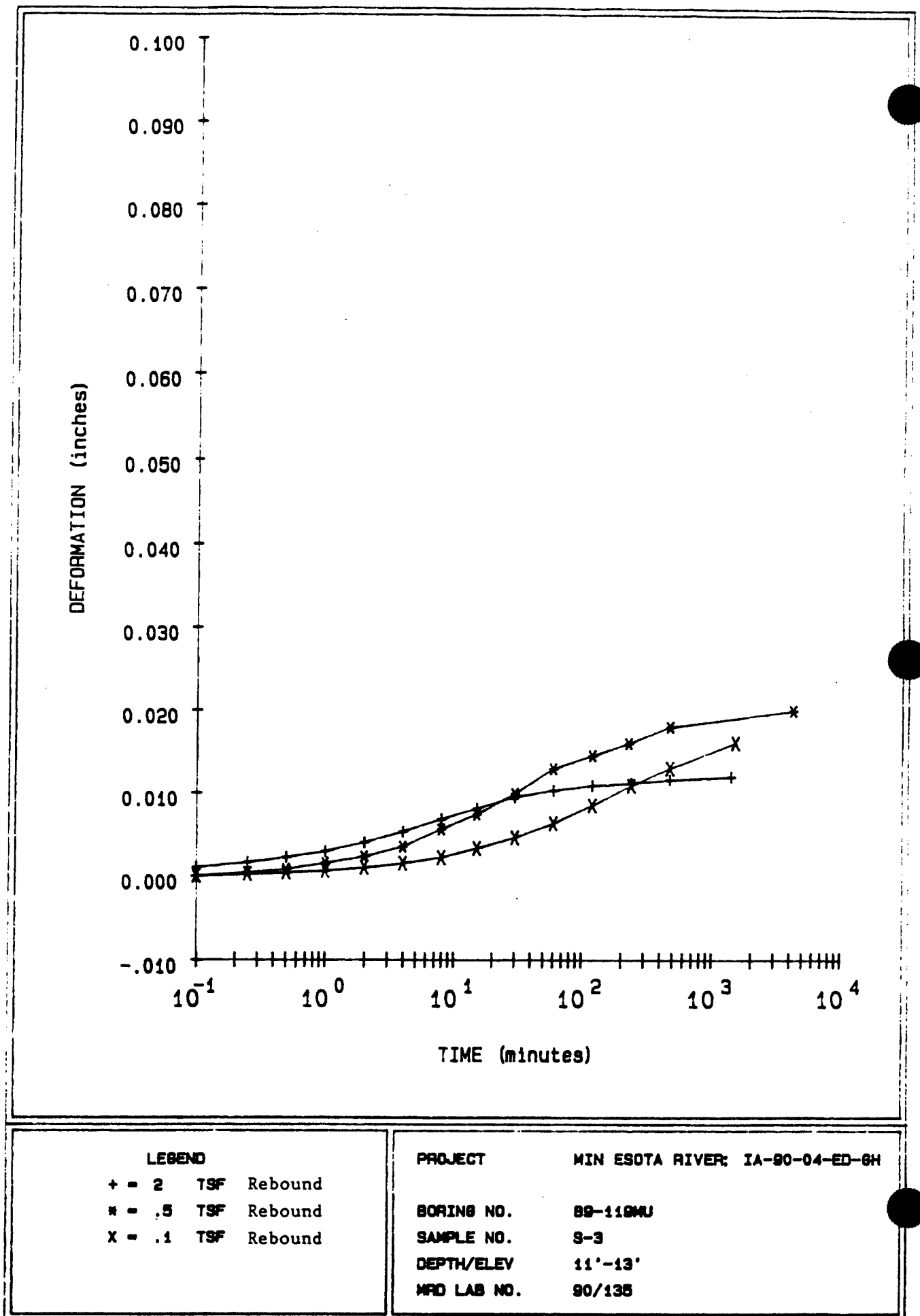


FIGURE 4



# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-119MU

Sample No. S-3

Depth/Elev 11'-13'

MRD Lab No. 90/135

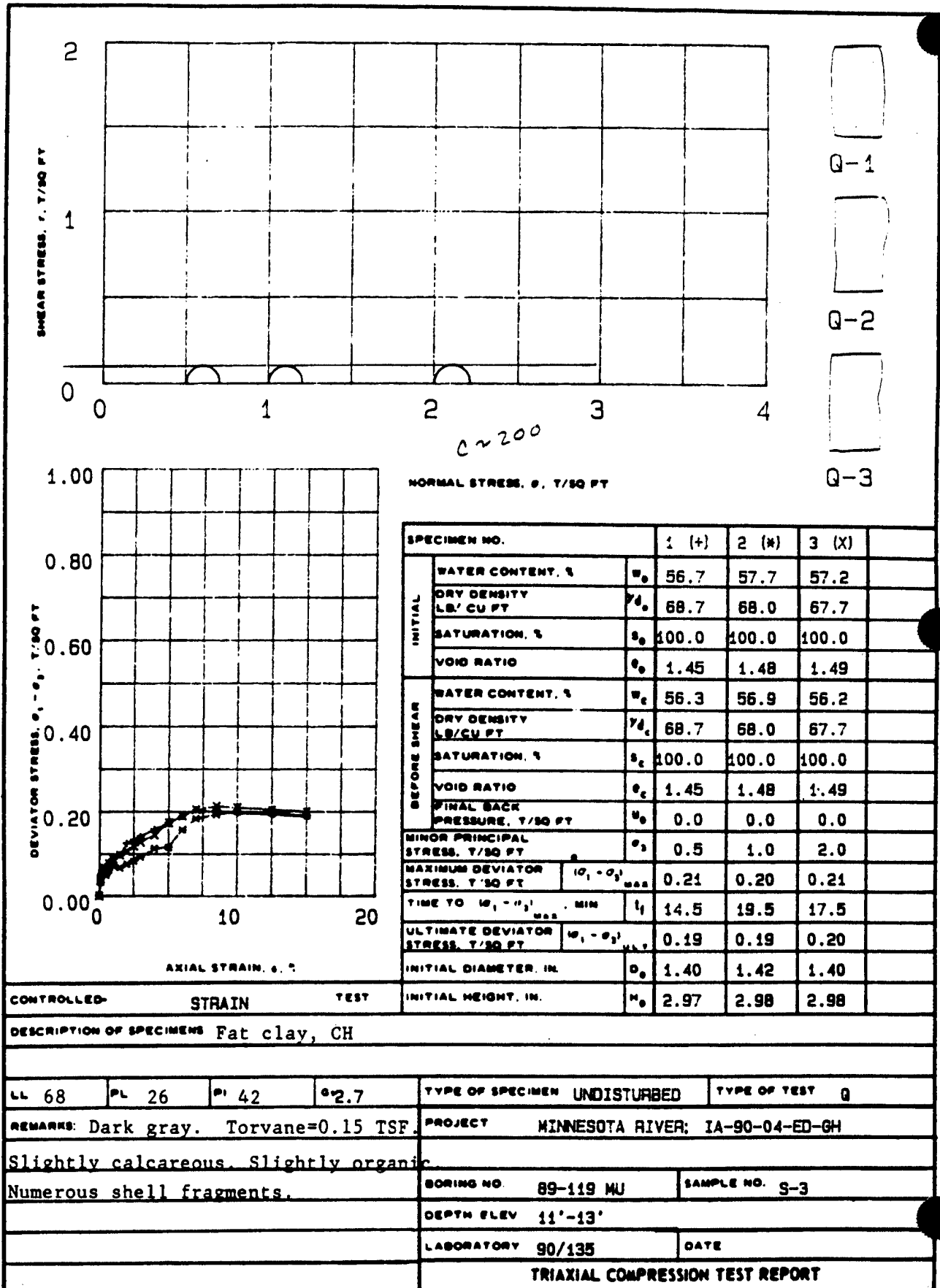
Gs = 2.7

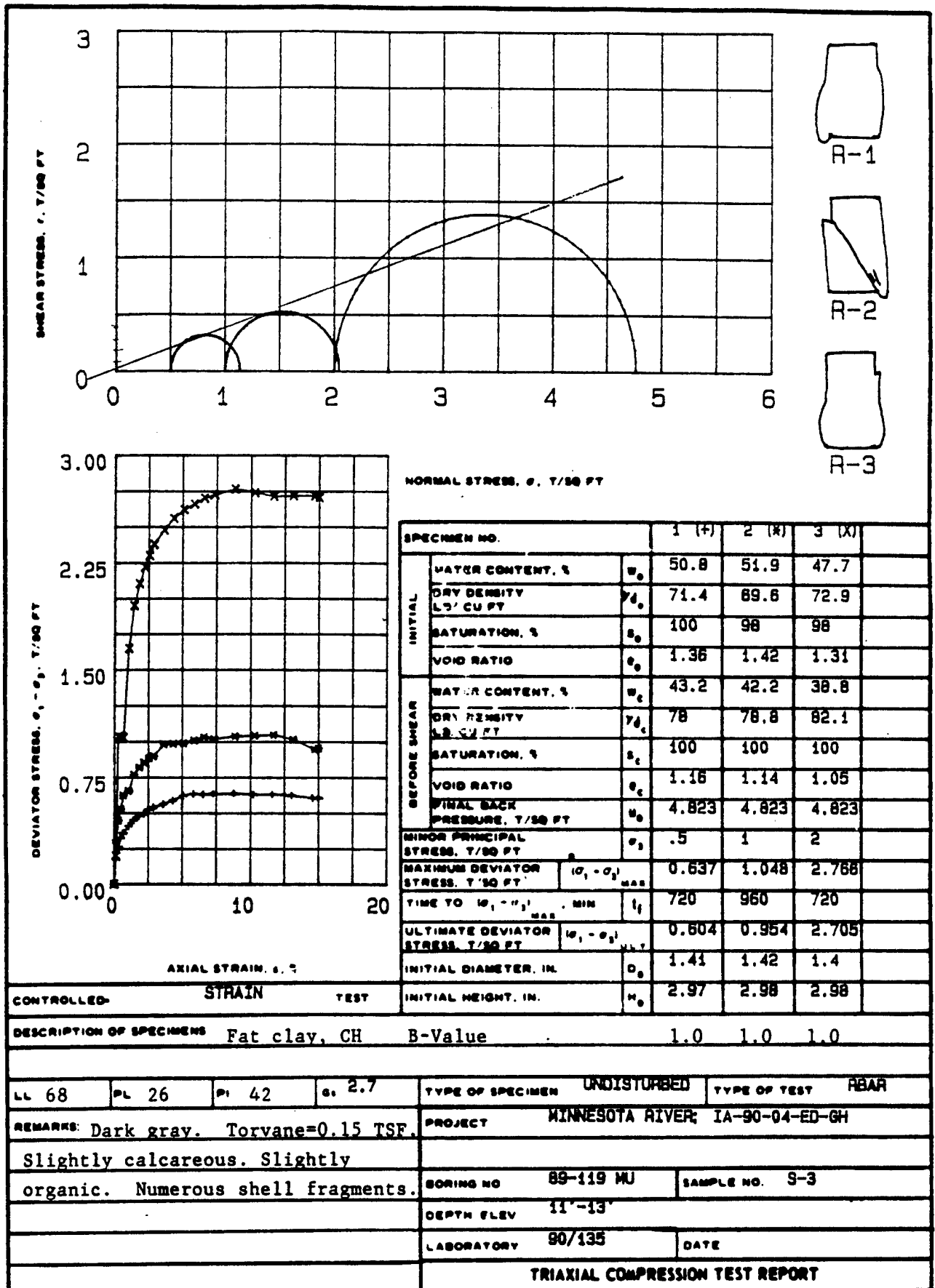
eo = 1.363

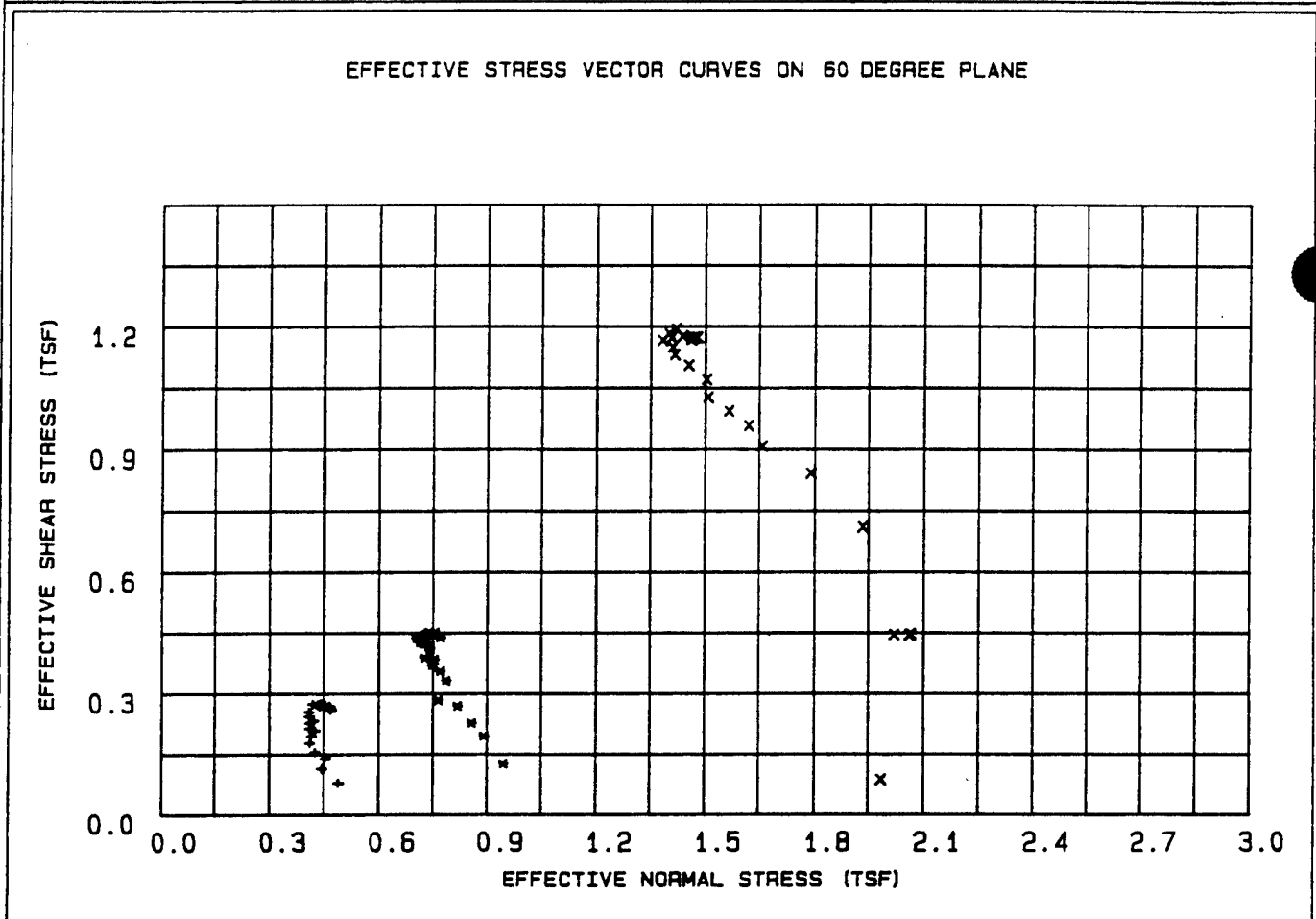
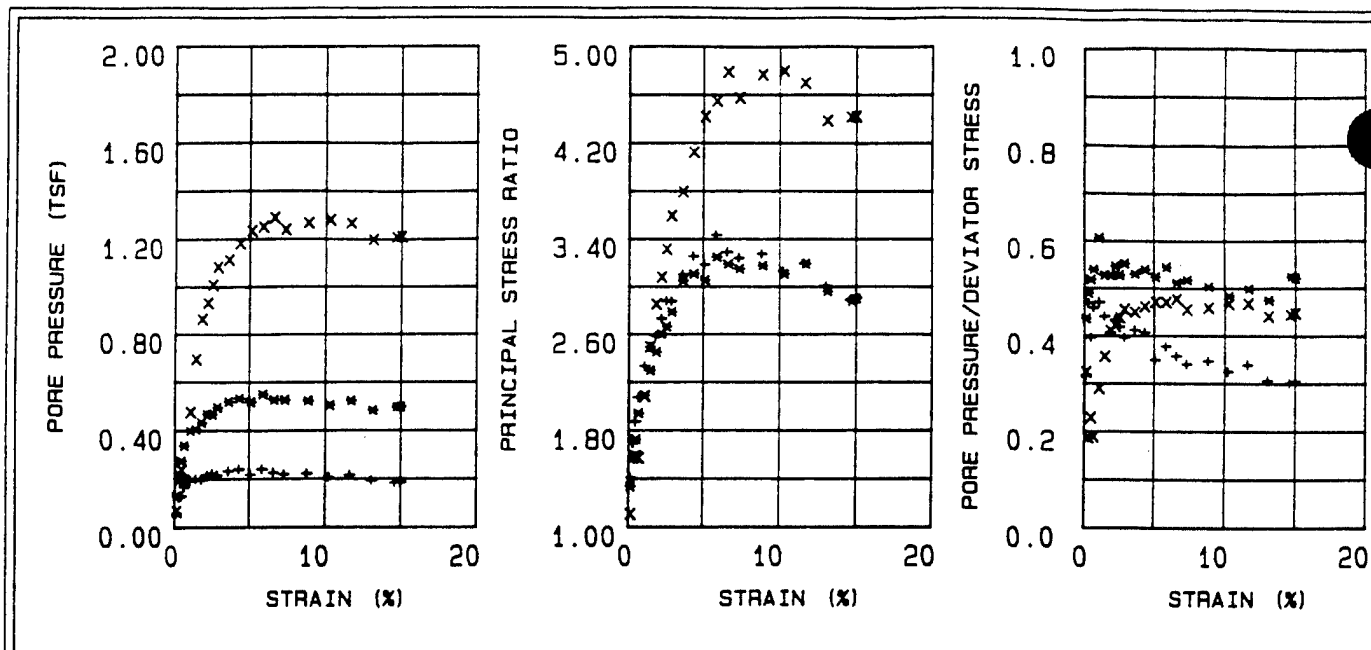
0.42eo = 0.572

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
55.3	289.7	71.3	1.363		100.0
35.7	289.7	72.8	1.315	0.10	73.3
35.7	289.7	73.5	1.293	0.25	74.6
35.7	289.7	75.8	1.221	0.50	78.9
35.7	289.7	79.2	1.127	1.00	85.5
35.7	289.7	83.8	1.011	2.00	95.4
35.7	289.7	89.5	0.883	4.00	100.0
35.7	289.7	96.0	0.755	8.00	100.0
35.7	289.7	94.5	0.783	2.00	100.0
35.7	289.7	92.0	0.831	0.50	100.0
35.7	289.7	90.2	0.869	0.10	100.0

Axial Strain (%)	Void Ratio
1	1.339
2	1.315
3	1.292
4	1.268
5	1.244
6	1.221
7	1.197
8	1.174
9	1.150
10	1.126
11	1.103







<b>LEGEND</b> + = .5 TSF * = 1 TSF x = 2 TSF	
<b>PROJECT</b>	MINNESOTA RIVER: IA-90-04-ED-GH
<b>BORING NO.</b>	89-119 MU
<b>SAMPLE NO.</b>	S-3
<b>DEPTH/ELEV</b>	11'-13'
<b>MRO LAB NO.</b>	90/135

FIGURE 7

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-3  
 Depth : 11'-13'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.15	0.180	0.057	1.406	0.316	0.488	0.078
30	0.32	0.262	0.122	1.693	0.468	0.443	0.113
45	0.49	0.325	0.128	1.873	0.395	0.452	0.140
60	0.69	0.359	0.165	2.072	0.458	0.424	0.155
90	1.08	0.410	0.192	2.331	0.470	0.409	0.177
120	1.45	0.451	0.198	2.492	0.440	0.414	0.194
150	1.84	0.482	0.195	2.580	0.406	0.424	0.208
180	2.21	0.495	0.214	2.730	0.433	0.408	0.213
210	2.53	0.526	0.220	2.879	0.418	0.410	0.227
240	2.88	0.539	0.213	2.876	0.395	0.420	0.233
300	3.61	0.564	0.232	3.101	0.411	0.408	0.243
360	4.32	0.589	0.239	3.253	0.406	0.407	0.254
420	5.06	0.621	0.216	3.183	0.348	0.438	0.268
4	5.82	0.635	0.239	3.431	0.377	0.418	0.274
540	6.56	0.631	0.224	3.289	0.356	0.432	0.272
600	7.29	0.636	0.216	3.237	0.339	0.442	0.275
720	8.79	<u>0.637</u>	<u>0.220</u>	3.273	0.346	0.438	0.275
840	10.22	0.629	0.204	3.125	0.324	0.452	0.272
960	11.60	0.630	0.213	3.193	0.338	0.443	0.272
1080	13.02	0.622	0.189	3.002	0.305	0.465	0.268
1200	14.57	0.603	0.181	2.888	0.300	0.468	0.260
1231	15.00	0.604	0.183	2.907	0.304	0.466	0.261

Table 2 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-3  
 Depth : 11'-13'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.15	0.291	0.127	1.333	0.435	0.945	0.126
30	0.32	0.449	0.219	1.576	0.489	0.892	0.194
45	0.50	0.527	0.273	1.725	0.518	0.857	0.227
60	0.69	0.624	0.336	1.940	0.539	0.818	0.269
90	1.09	0.657	0.398	2.091	0.606	0.765	0.284
120	1.46	0.770	0.405	2.294	0.527	0.786	0.332
150	1.86	0.822	0.433	2.450	0.527	0.770	0.355
180	2.23	0.854	0.467	2.602	0.547	0.745	0.369
210	2.55	0.887	0.467	2.664	0.527	0.753	0.383
240	2.90	0.900	0.496	2.787	0.552	0.727	0.388
300	3.64	0.982	0.520	3.048	0.530	0.723	0.424
360	4.36	0.987	0.532	3.106	0.539	0.712	0.426
420	5.11	0.990	0.517	3.052	0.523	0.728	0.427
480	5.88	1.012	0.550	3.248	0.544	0.701	0.437
500	6.62	1.034	0.527	3.187	0.511	0.729	0.440
600	7.36	1.018	0.526	3.146	0.517	0.726	0.439
720	8.88	1.040	0.522	3.174	0.502	0.735	0.449
840	10.32	1.044	0.503	3.102	0.483	0.755	0.451
960	11.71	<del>1.048</del>	<del>0.522</del>	3.191	0.498	0.738	0.452
1080	13.14	1.015	0.481	2.956	0.474	0.770	0.438
1200	14.71	0.946	0.495	2.872	0.524	0.739	0.408
1221	15.00	0.954	0.497	2.897	0.521	0.739	0.412

Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-3  
 Depth : 11'-13'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.15	0.199	0.064	1.103	0.323	1.985	0.086
30	0.32	1.035	0.192	1.573	0.186	2.064	0.447
45	0.50	1.032	0.235	1.585	0.228	2.020	0.445
60	0.69	1.028	0.192	1.568	0.188	2.062	0.444
90	1.09	1.648	0.475	2.081	0.289	1.933	0.711
120	1.46	1.951	0.694	2.494	0.356	1.789	0.842
150	1.85	2.105	0.863	2.851	0.411	1.658	0.908
180	2.22	2.221	0.931	3.077	0.420	1.619	0.958
210	2.55	2.301	1.006	3.314	0.438	1.564	0.993
240	2.89	2.380	1.082	3.593	0.455	1.507	1.027
300	3.63	2.479	1.112	3.793	0.449	1.502	1.070
360	4.35	2.561	1.180	4.123	0.461	1.454	1.105
420	5.09	2.621	1.233	4.419	0.471	1.416	1.131
480	5.86	2.662	1.249	4.547	0.470	1.410	1.149
540	6.60	2.702	1.287	4.789	0.477	1.382	1.166
600	7.34	2.725	1.237	4.571	0.454	1.438	1.176
720	8.85	2.766	1.265	4.765	0.458	1.420	1.194
840	10.29	2.740	1.278	4.794	0.467	1.400	1.182
960	11.67	2.714	1.265	4.695	0.467	1.407	1.172
1080	13.11	2.719	1.196	4.382	0.440	1.477	1.173
1200	14.66	2.716	1.205	4.416	0.444	1.467	1.172
1224	15.00	2.705	1.209	4.418	0.447	1.461	1.167

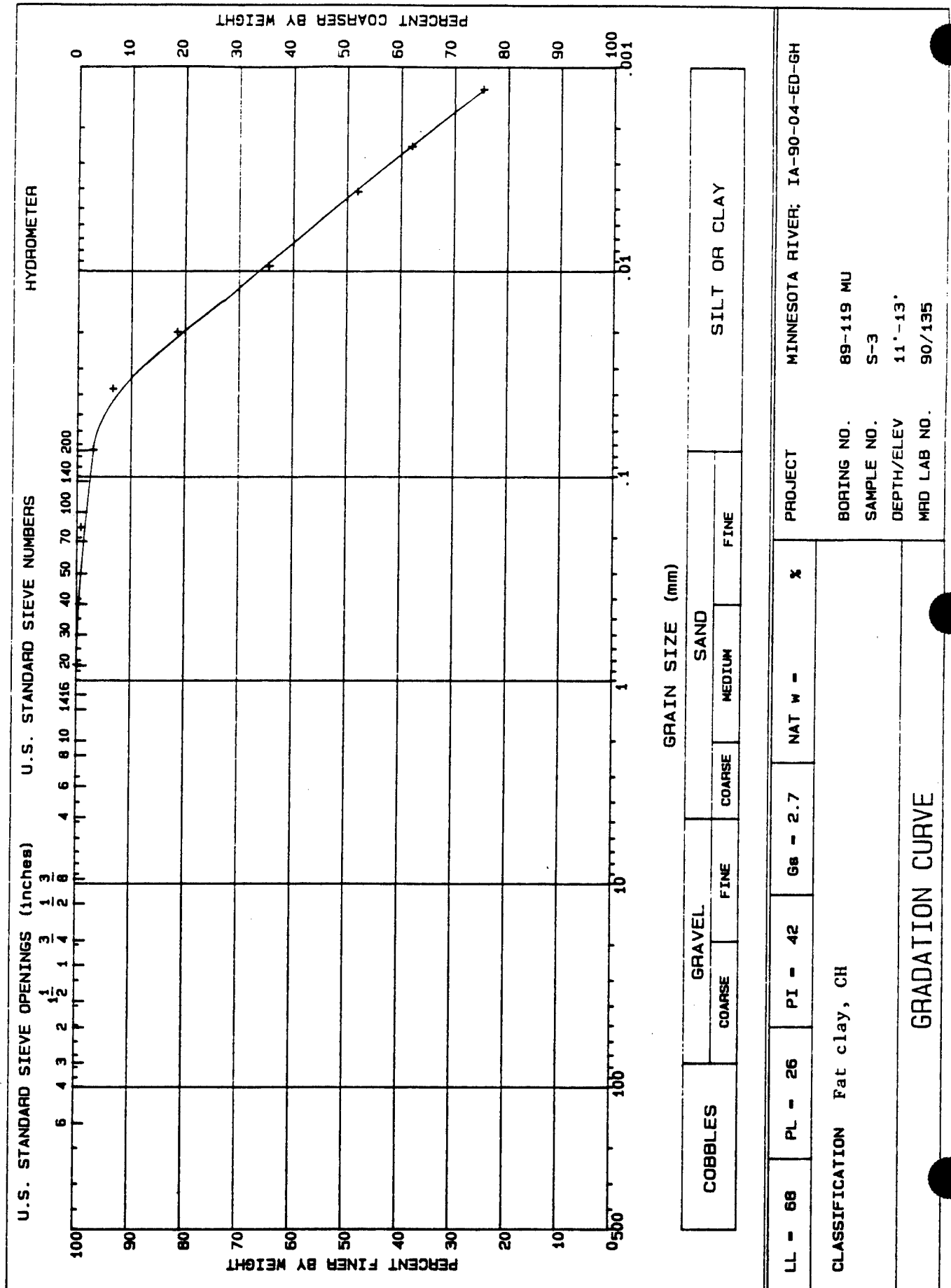
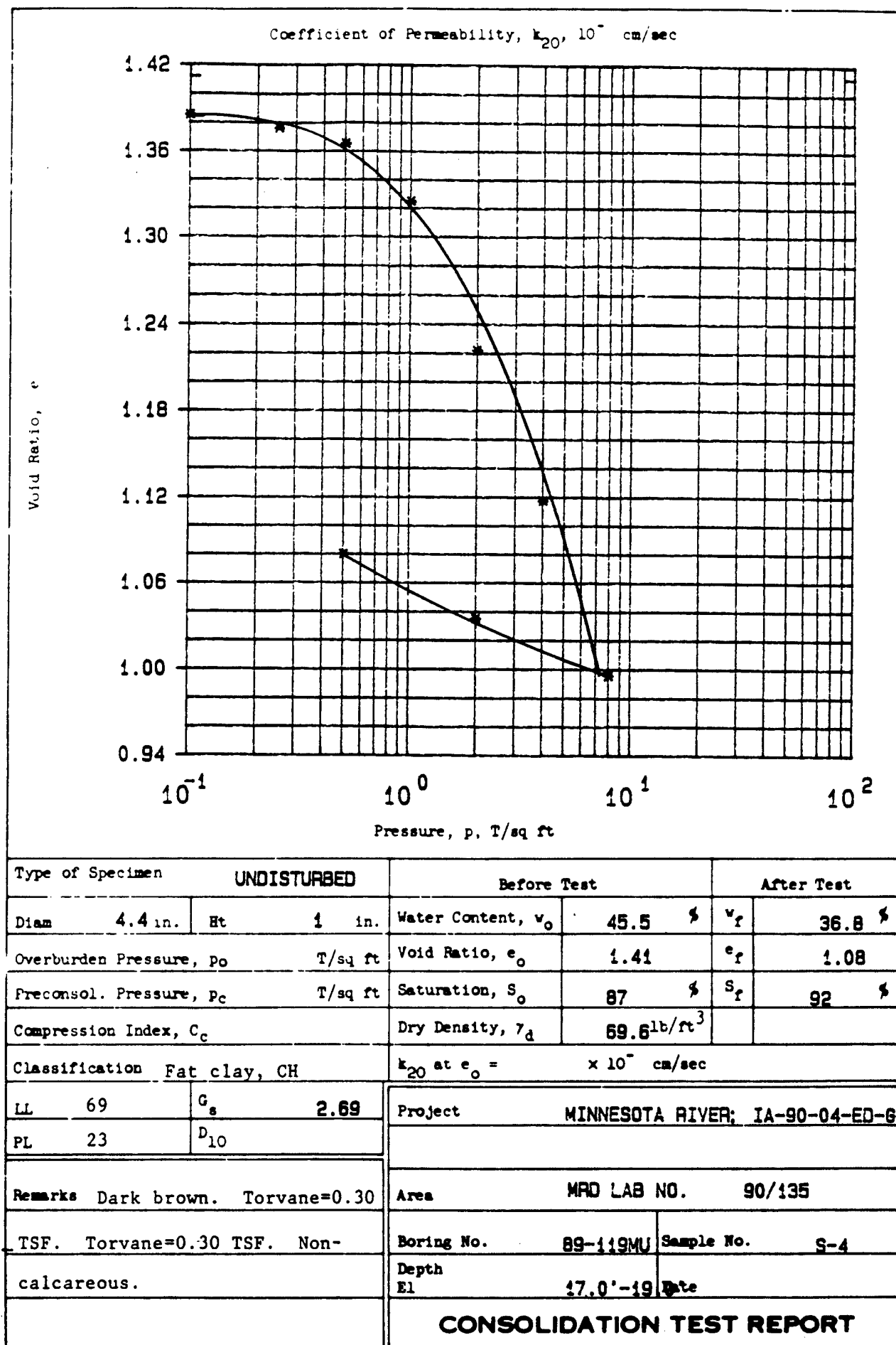


FIGURE 8





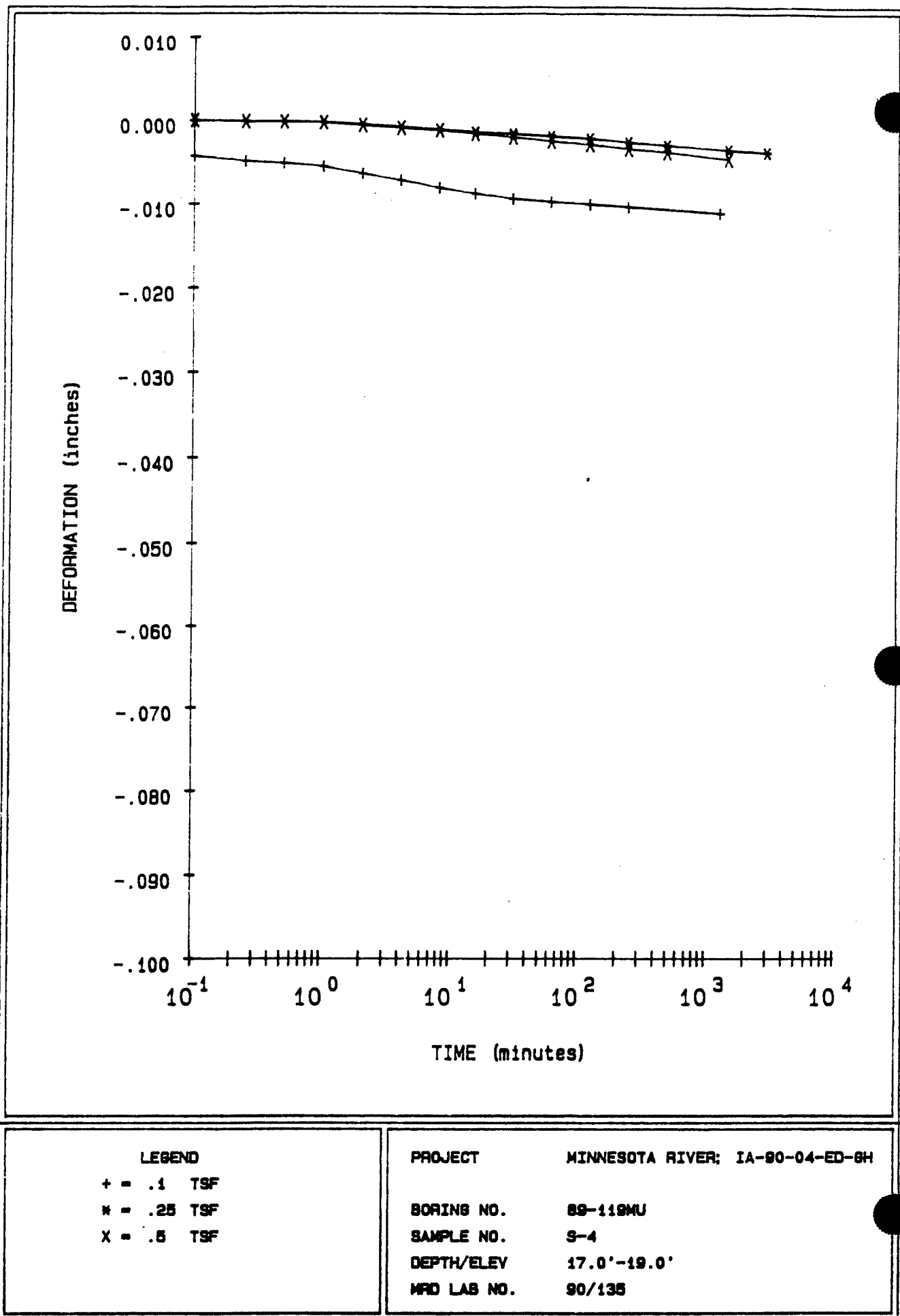
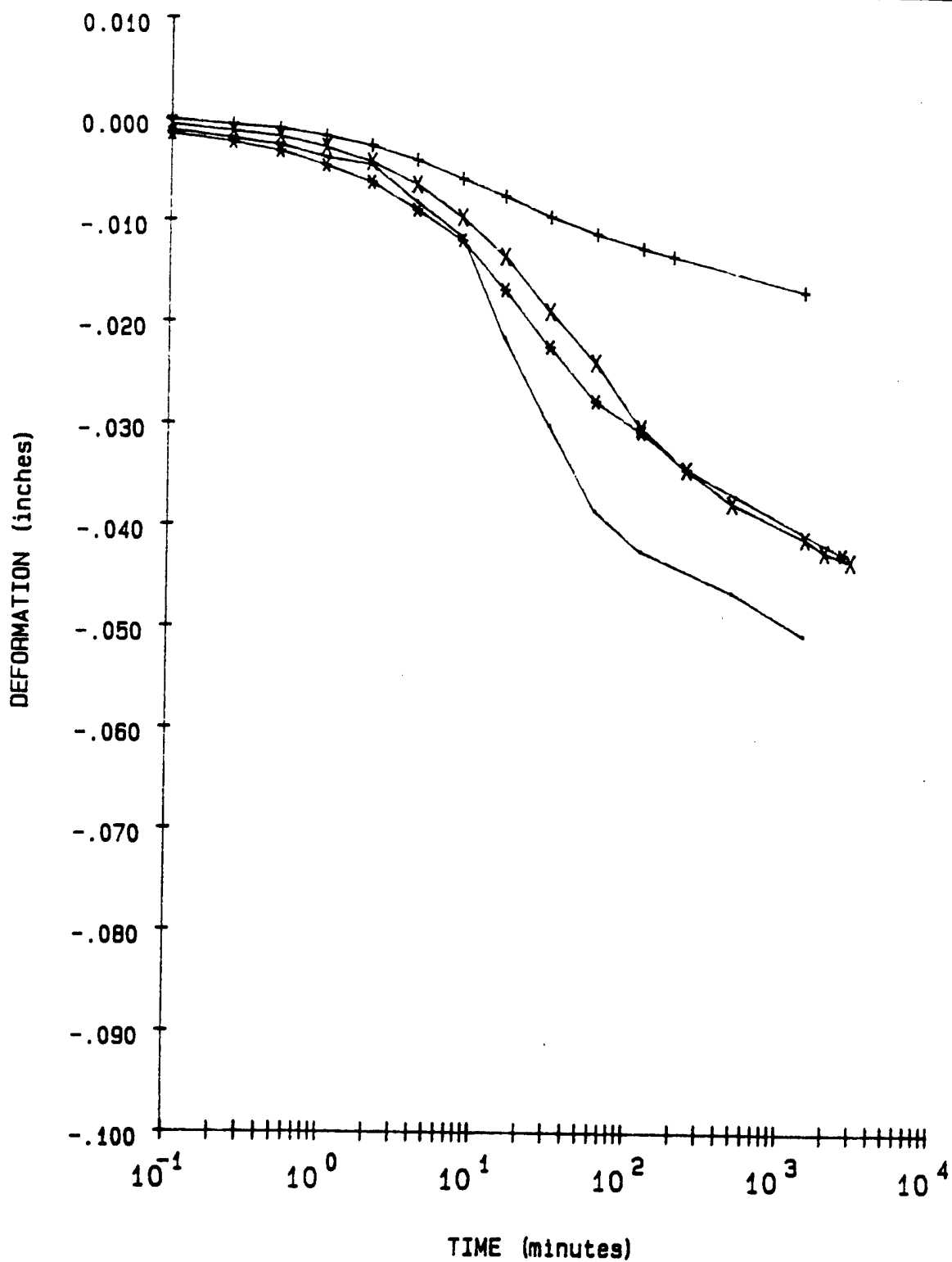


FIGURE 10



**LEGEND**

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

**PROJECT**

MINNESOTA RIVER; IA-90-04-ED-6H

**BORING NO.**

89-119MU

**SAMPLE NO.**

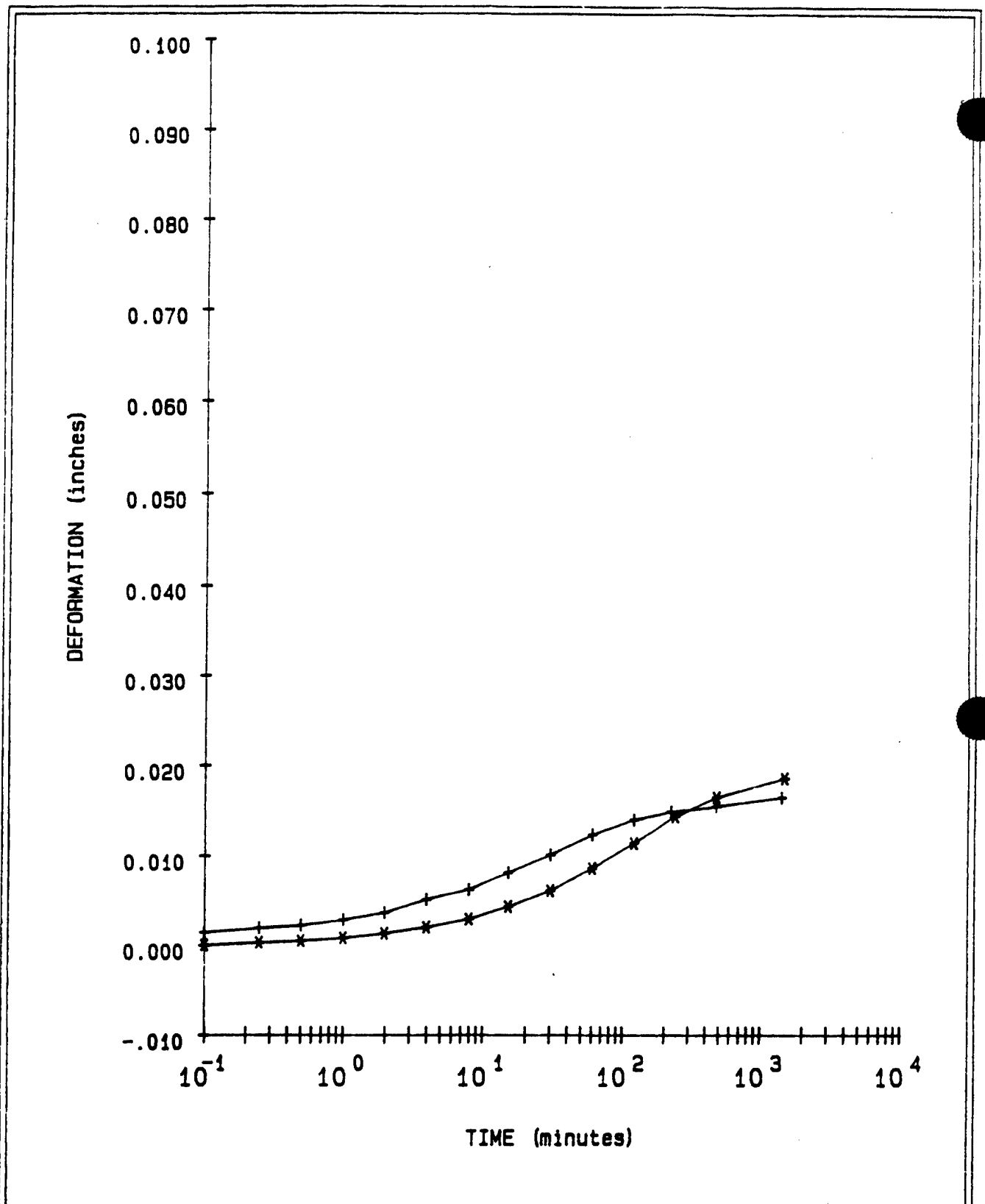
S-4

**DEPTH/ELEV**

17.0'-19.0'

**MRD LAB NO.**

90/135



LEGEND

- + = 2 TSF Rebound
- \* = .5 TSF Rebound

PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO.

89-119MU

SAMPLE NO.

S-4

DEPTH/ELEV

17.0'-19.0'

MRD LAB NO.

90/135

FIGURE 12

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-119MU

Sample No. S-4

Depth/Elev 17.0'-19.0'

MRD Lab No. 90/135

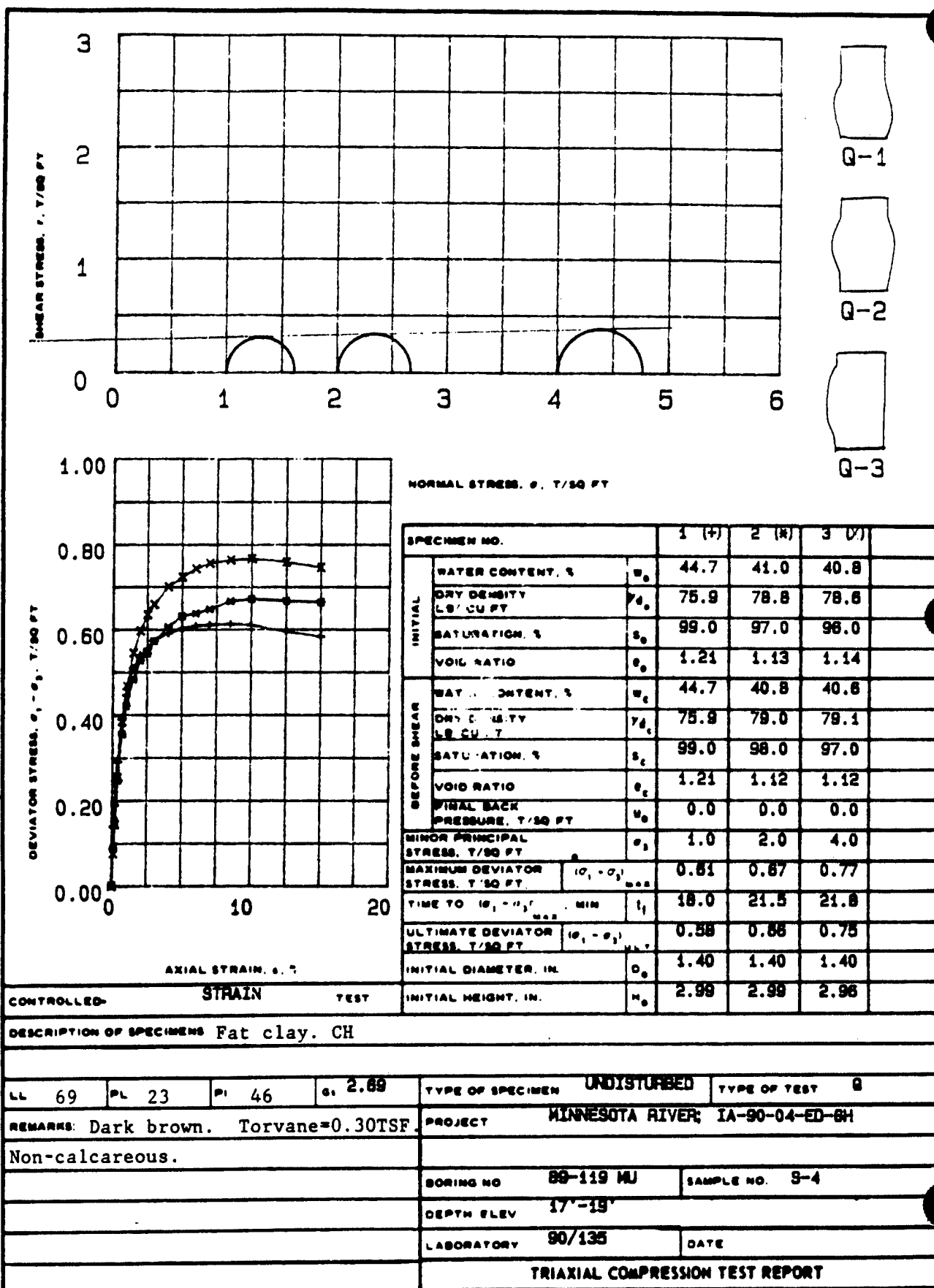
Gs = 2.69

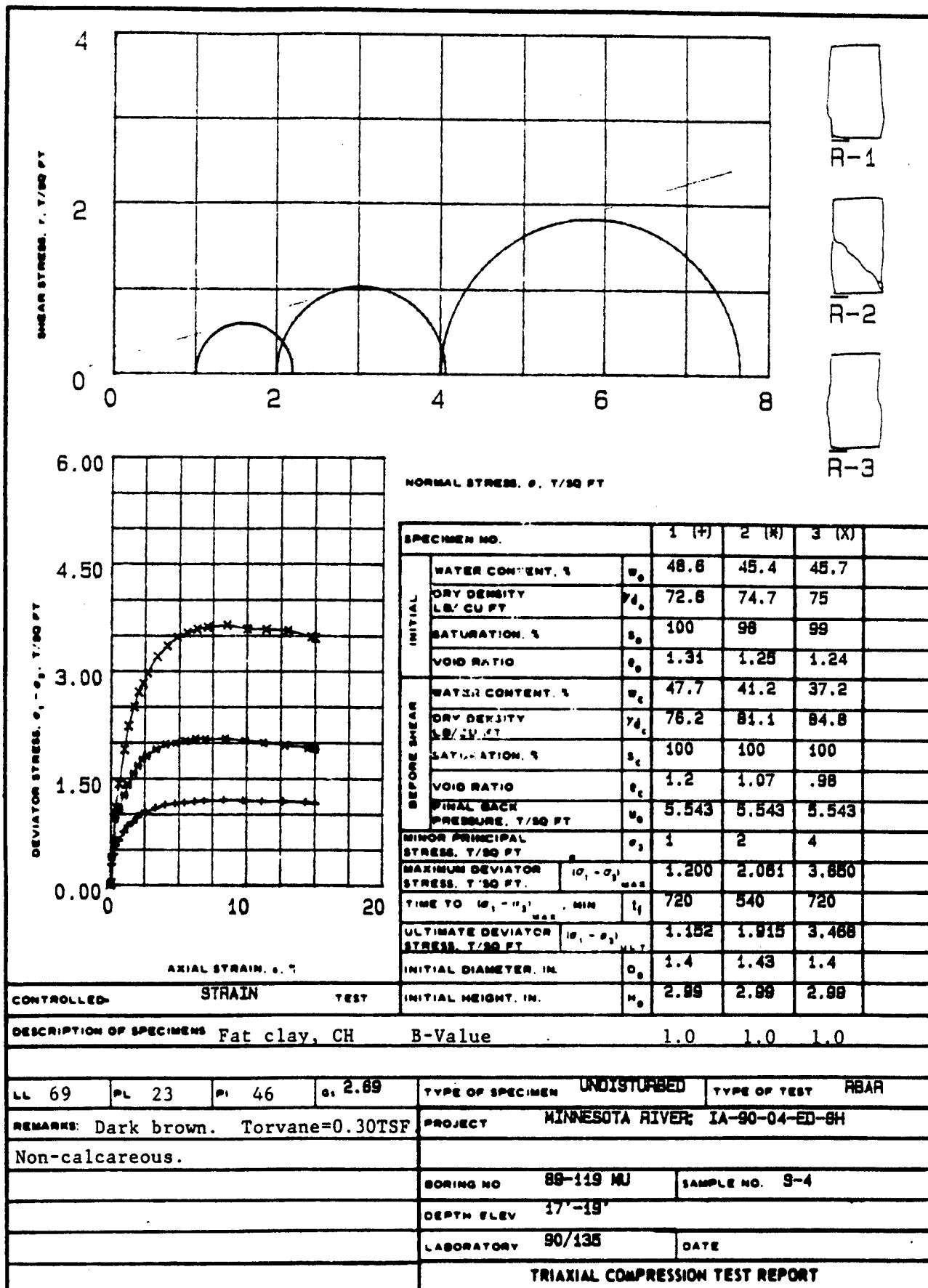
eo = 1.412

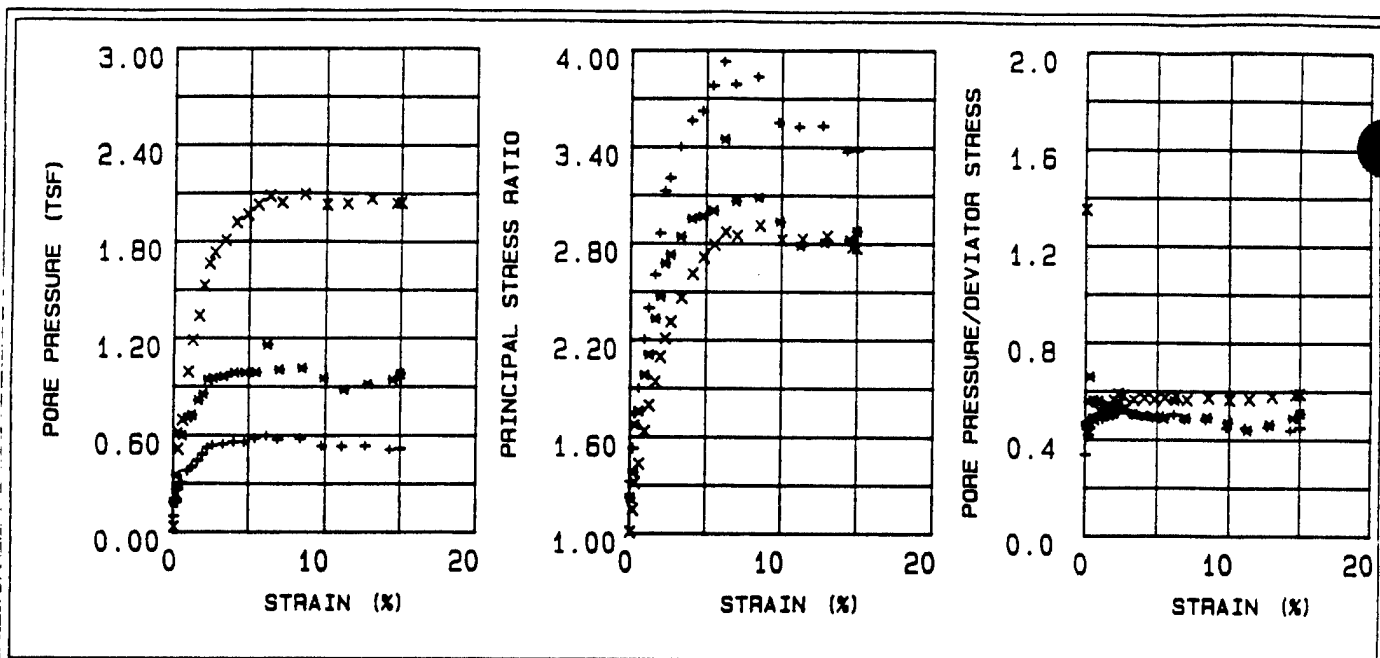
0.42eo = 0.593

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
45.5	282.7	69.6	1.412		86.6
36.8	282.7	70.4	1.385	0.10	71.5
36.8	282.7	70.6	1.376	0.25	72.0
36.8	282.7	71.0	1.365	0.50	72.6
36.8	282.7	72.2	1.325	1.00	74.8
36.8	282.7	75.5	1.222	2.00	81.1
36.8	282.7	79.3	1.117	4.00	88.6
36.8	282.7	84.1	0.995	8.00	99.5
36.8	282.7	82.5	1.035	2.00	95.7
36.8	282.7	80.7	1.080	0.50	91.7

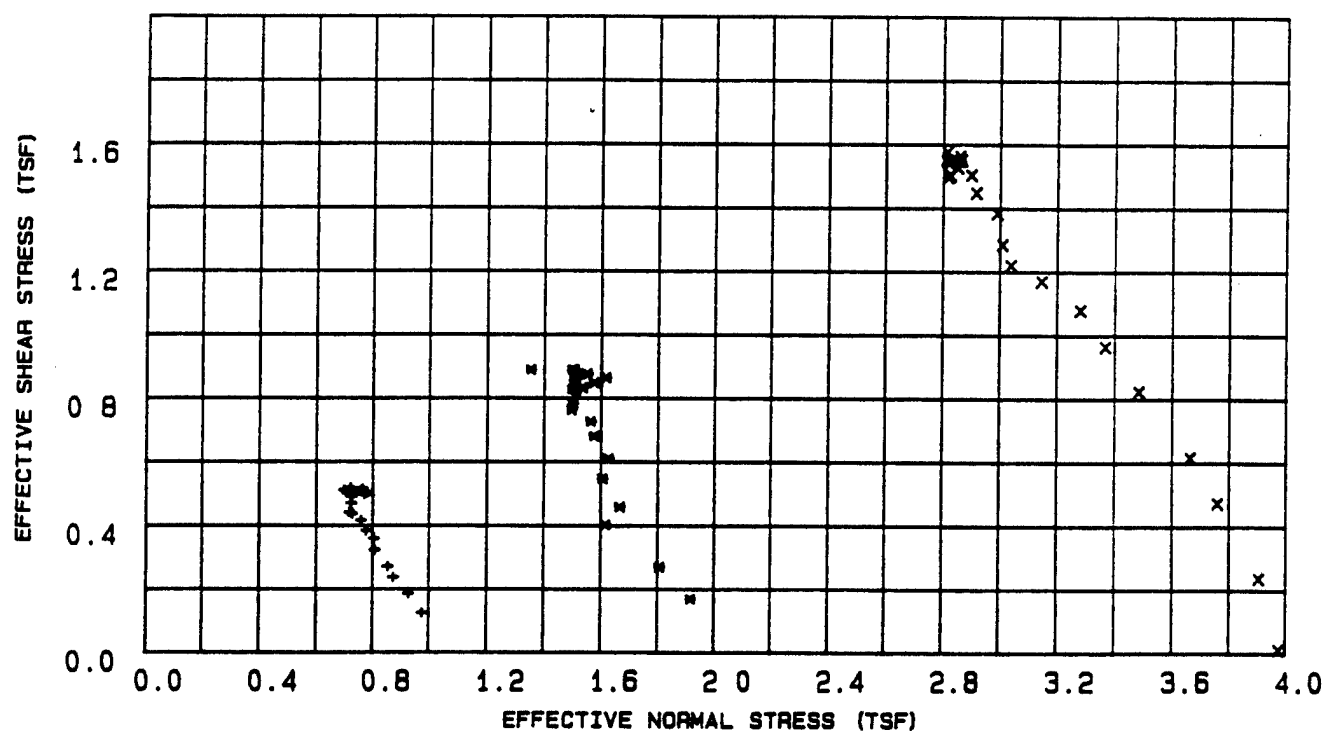
Axial Strain (%)	Void Ratio
1	1.388
2	1.364
3	1.340
4	1.316
5	1.291
6	1.267
7	1.243
8	1.219
9	1.195
10	1.171
11	1.147
12	1.123
13	1.098
14	1.074
15	1.050
16	1.026
17	1.002
18	0.978
19	0.954
20	0.930







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

- + = 1 TSF
- \* = 2 TSF
- x = 4 TSF

PROJECT

MINNESOTA RIVER IA-90-04-ED-GH

BORING NO.

89-119 MU

SAMPLE NO.

S-4

DEPTH/ELEV

17'-19'

MWD LAB NO.

90/135

FIGURE 15



R

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-4  
 Depth : 17'-19'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.288	0.097	1.319	0.337	0.974	0.124
30	0.24	0.432	0.182	1.528	0.421	0.925	0.186
45	0.34	0.549	0.264	1.746	0.480	0.872	0.237
60	0.60	0.627	0.303	1.900	0.484	0.852	0.271
90	0.97	0.748	0.379	2.204	0.507	0.806	0.323
120	1.24	0.834	0.403	2.397	0.484	0.803	0.360
150	1.65	0.889	0.445	2.603	0.501	0.775	0.384
180	1.96	0.964	0.482	2.861	0.500	0.757	0.416
210	2.28	1.012	0.524	3.124	0.518	0.726	0.437
240	2.61	1.023	0.537	3.207	0.525	0.716	0.441
300	3.29	1.088	0.546	3.400	0.503	0.723	0.470
360	4.00	1.135	0.557	3.563	0.491	0.724	0.490
420	4.70	1.155	0.559	3.620	0.485	0.727	0.498
480	5.40	1.165	0.581	3.780	0.499	0.707	0.503
540	6.13	1.183	0.596	3.929	0.504	0.697	0.511
600	6.88	1.192	0.572	3.787	0.481	0.723	0.515
720	8.36	<del>1.200</del>	<del>0.577</del>	3.835	0.481	0.720	0.518
840	9.76	1.193	0.532	3.551	0.447	0.763	0.515
960	11.12	1.185	0.530	3.524	0.448	0.763	0.512
1080	12.69	1.180	0.533	3.530	0.452	0.759	0.509
1200	14.31	1.165	0.509	3.372	0.437	0.780	0.503
1252	15.00	1.152	0.516	3.382	0.449	0.769	0.497

Table 5 - Triaxial  $\bar{R}$  Test Results

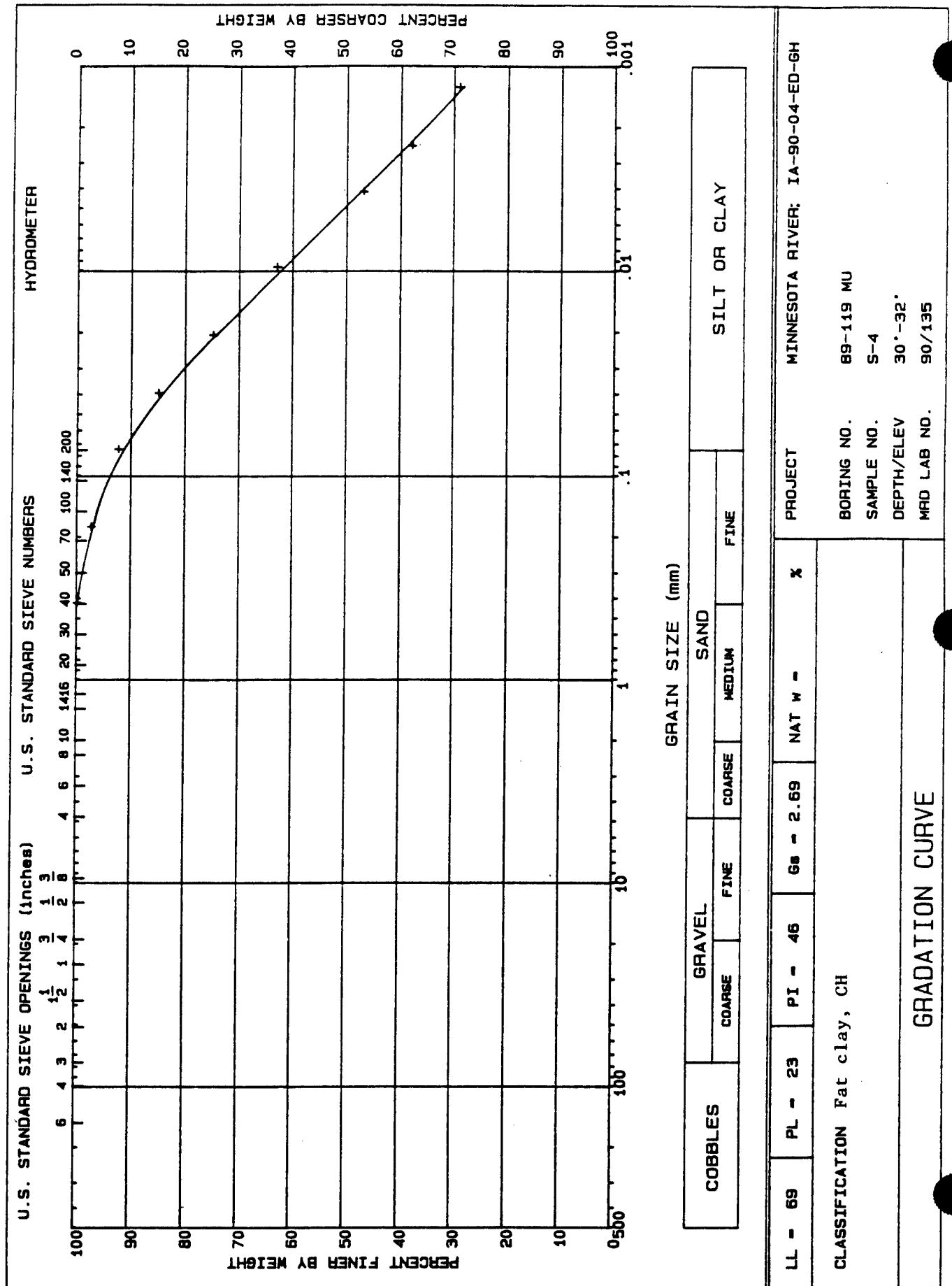
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-4  
 Depth : 17'-19'  
 Confining Pressure : 2 TSF

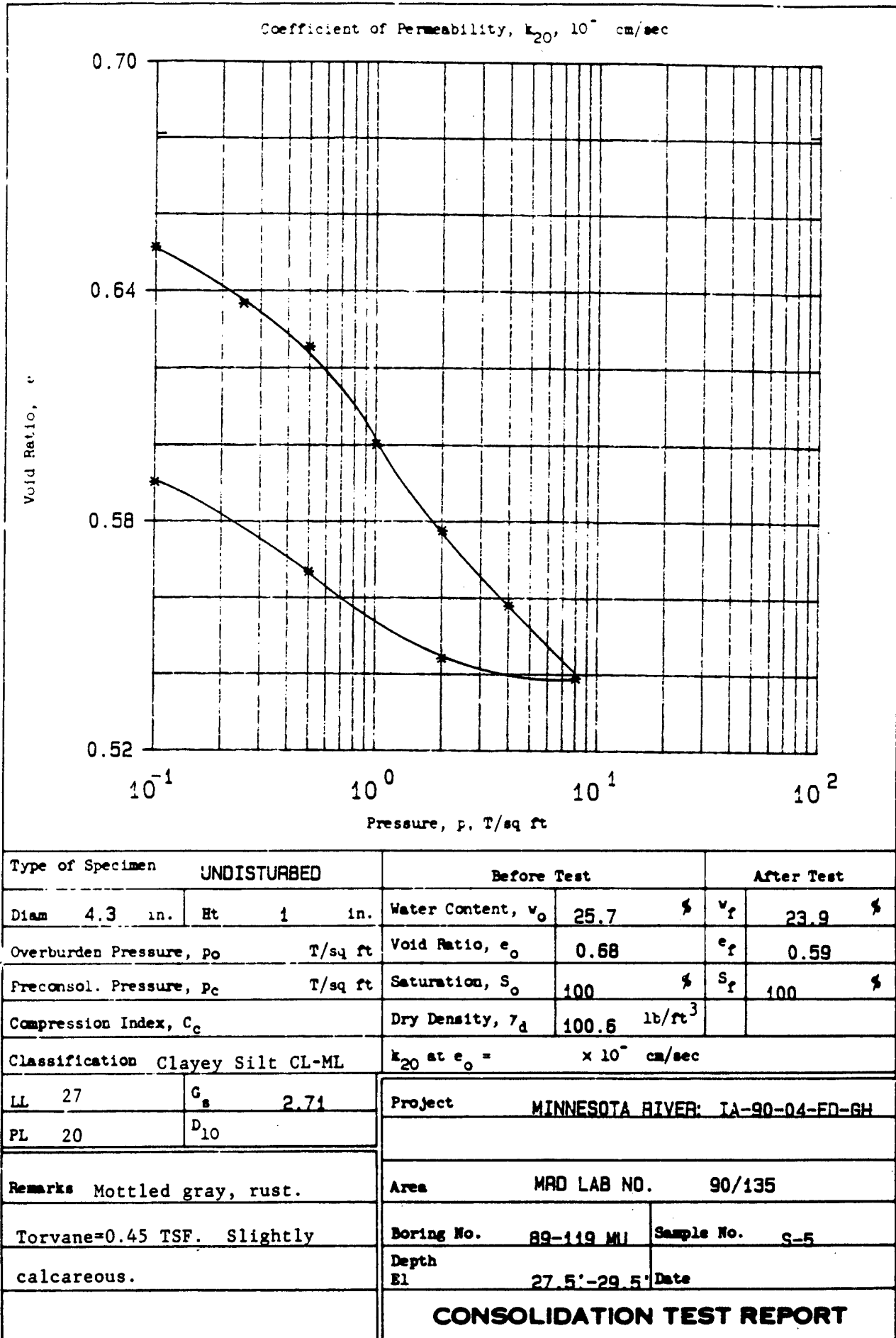
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.395	0.181	1.217	0.459	1.917	0.170
30	0.24	0.625	0.348	1.378	0.556	1.807	0.270
45	0.34	0.934	0.615	1.674	0.660	1.616	0.403
60	0.61	1.064	0.596	1.758	0.561	1.667	0.459
90	0.98	1.268	0.709	1.982	0.560	1.605	0.547
120	1.25	1.415	0.724	2.109	0.512	1.626	0.611
150	1.67	1.577	0.816	2.332	0.518	1.575	0.681
180	1.99	1.683	0.855	2.470	0.508	1.562	0.727
210	2.30	1.770	0.943	2.675	0.534	1.495	0.764
240	2.65	1.817	0.951	2.731	0.524	1.499	0.784
300	3.33	1.910	0.963	2.841	0.505	1.510	0.824
360	4.05	1.982	0.986	2.954	0.498	1.505	0.855
420	4.76	1.997	0.986	2.969	0.494	1.508	0.862
480	5.47	2.029	0.988	3.005	0.487	1.514	0.876
540	6.20	2.061	1.158	3.448	0.562	1.352	0.889
600	6.96	2.054	1.004	3.062	0.489	1.505	0.887
720	8.46	2.059	1.013	3.085	0.492	1.497	0.889
840	9.88	2.030	0.951	2.934	0.469	1.551	0.876
960	11.25	2.001	0.878	2.783	0.439	1.617	0.864
1080	12.85	1.965	0.912	2.806	0.464	1.575	0.848
1200	14.49	1.927	0.943	2.824	0.490	1.534	0.832
1238	15.00	1.915	0.978	2.877	0.511	1.497	0.827

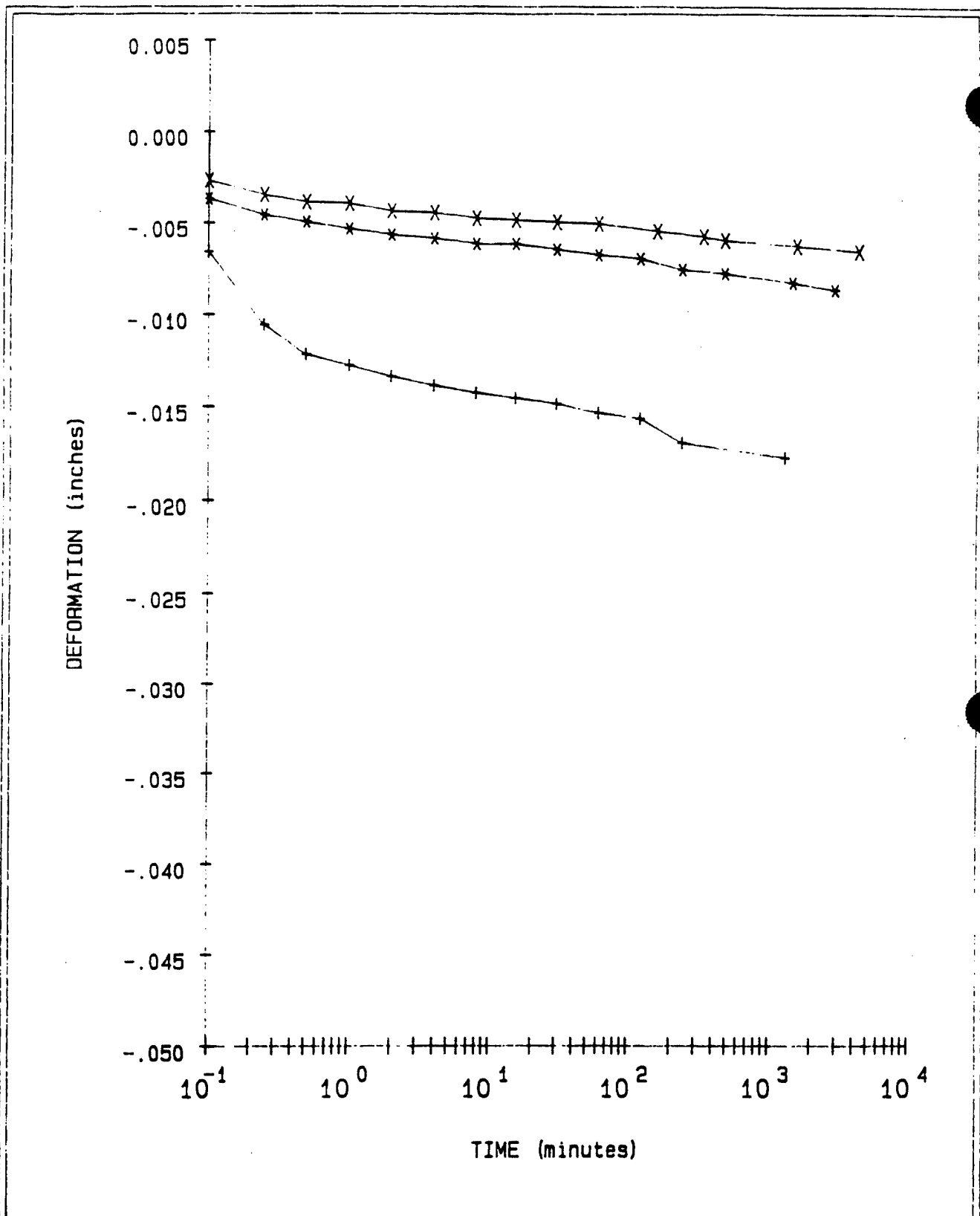
Table 6 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-4  
 Depth : 17'-19'  
 Confining Pressure : 4 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.023	0.030	1.006	1.350	3.976	0.010
30	0.25	0.550	0.232	1.146	0.423	3.904	0.237
45	0.35	1.095	0.513	1.314	0.469	3.758	0.473
60	0.62	1.428	0.692	1.432	0.485	3.662	0.616
90	0.99	1.906	0.989	1.633	0.519	3.483	0.823
120	1.27	2.234	1.186	1.794	0.531	3.367	0.964
150	1.69	2.499	1.338	1.939	0.536	3.281	1.079
180	2.01	2.710	1.525	2.095	0.563	3.146	1.170
210	2.33	2.827	1.662	2.209	0.588	3.038	1.220
240	2.68	2.979	1.730	2.312	0.581	3.008	1.286
300	3.38	3.206	1.806	2.461	0.564	2.988	1.384
360	4.10	3.356	1.916	2.610	0.572	2.915	1.448
420	4.82	3.484	1.966	2.713	0.565	2.897	1.504
480	5.54	3.539	2.026	2.793	0.573	2.850	1.527
540	6.29	3.591	2.080	2.870	0.580	2.809	1.550
600	7.06	3.623	2.038	2.847	0.563	2.859	1.564
720	8.57	3.650	2.091	2.912	0.573	2.813	1.576
840	10.01	3.593	2.026	2.821	0.564	2.864	1.551
960	11.40	3.588	2.034	2.825	0.567	2.854	1.549
1080	13.02	3.570	2.065	2.844	0.579	2.819	1.541
1200	14.68	3.482	2.038	2.774	0.586	2.824	1.503
1223	15.00	3.468	2.042	2.771	0.590	2.816	1.497







LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-119 MU

SAMPLE NO.

S-5

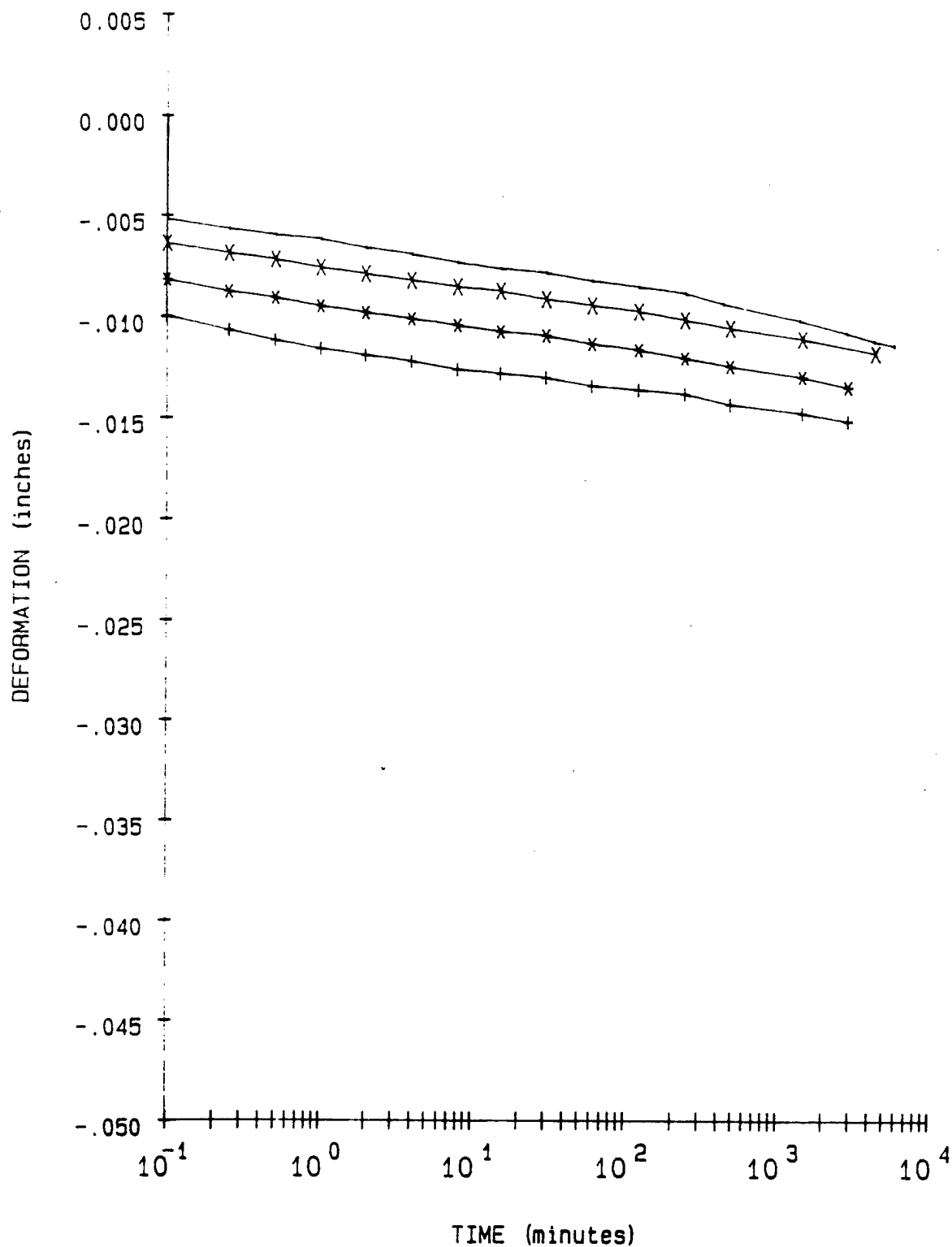
DEPTH/ELEV

27.5'-29.5'

MRD LAB NO.

90/135

FIGURE 2



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-119 MU

SAMPLE NO.

S-5

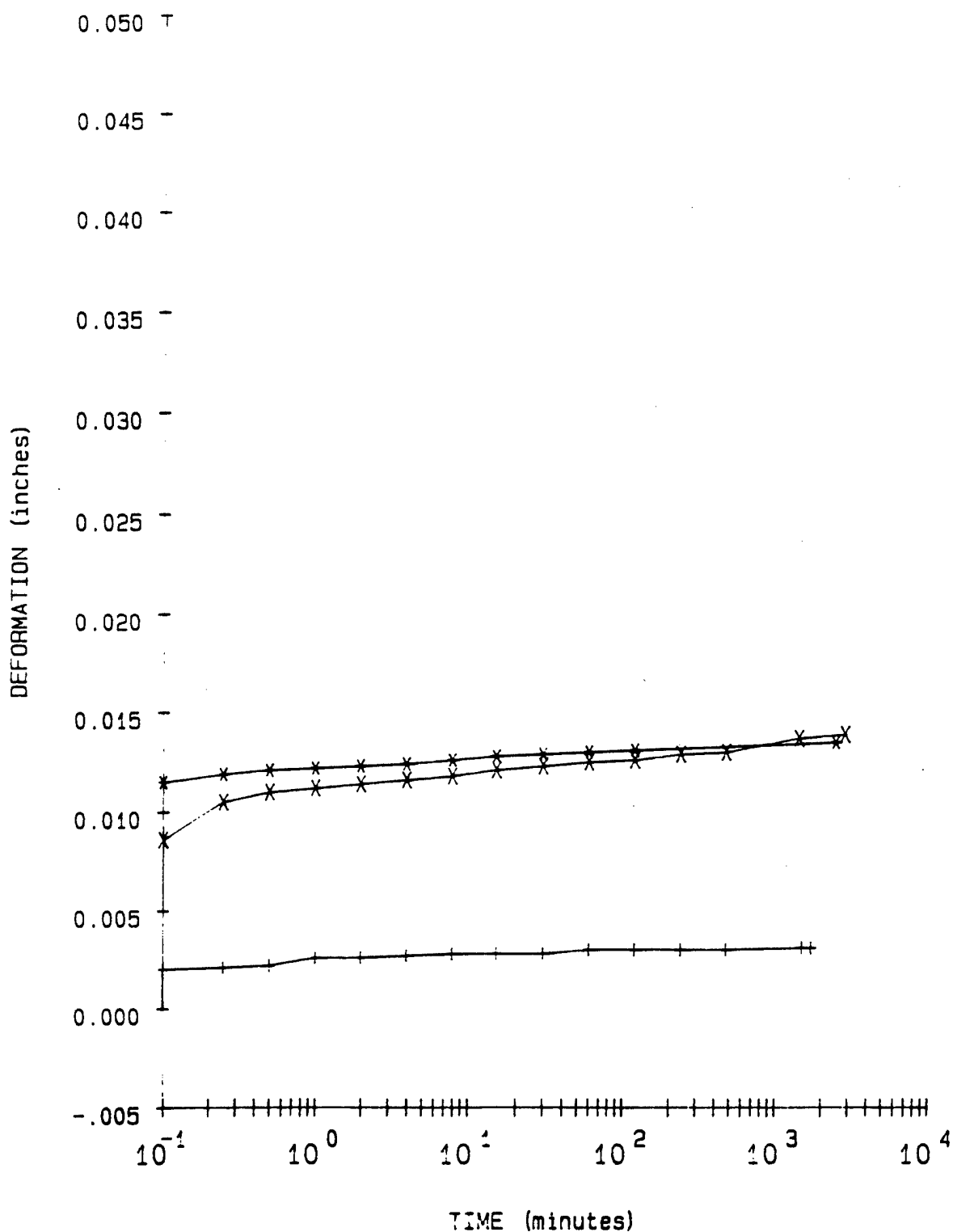
DEPTH/ELEV

27.5'-29.5'

MRD LAB NO.

90/135

FIGURE 3



LEGEND  
 + = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT MINNESOTA RIVER; IA-90-04-ED-6H  
 BORING NO. 89-119 MU  
 SAMPLE NO. S-5  
 DEPTH/ELEV 27.5'-29.5'  
 MRD LAB NO. 90/135

FIGURE 4



# Consolidation Test Data

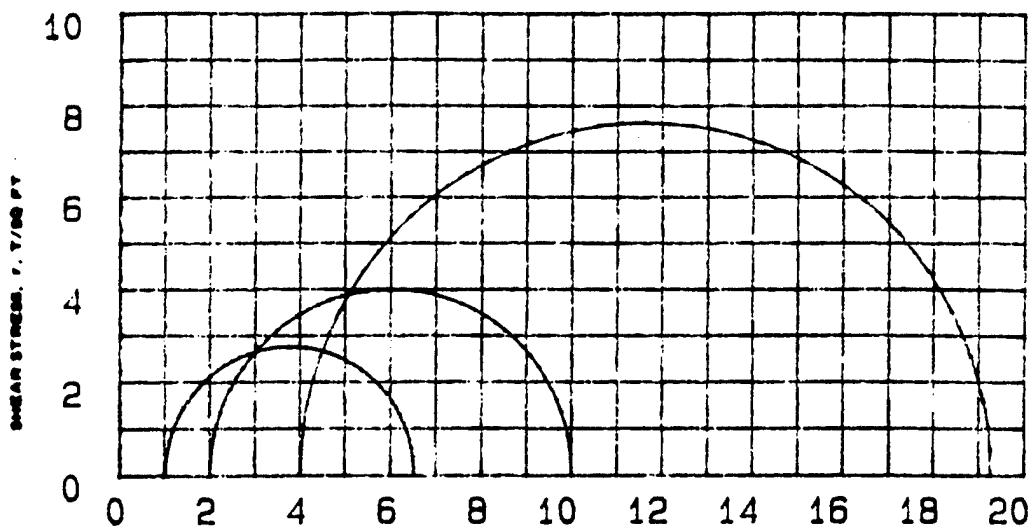
Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-119 MU  
Sample No. S-5  
Depth/Elev 27.5'-29.5'  
MRD Lab No. 90/135

Gs = 2.71  
eo = 0.681  
0.42eo = 0.286

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
25.7	378.1	100.6	0.681		100.0
23.9	378.1	102.4	0.651	0.10	99.2
23.9	378.1	103.3	0.637	0.25	100.0
23.9	378.1	104.0	0.625	0.50	100.0
23.9	378.1	105.7	0.600	1.00	100.0
23.9	378.1	107.2	0.578	2.00	100.0
23.9	378.1	108.5	0.558	4.00	100.0
3.9	378.1	109.9	0.539	8.00	100.0
23.9	378.1	109.5	0.544	2.00	100.0
23.9	378.1	107.9	0.567	0.50	100.0
23.9	378.1	106.3	0.590	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.664
2	0.648
3	0.631
4	0.614
5	0.597
6	0.580
7	0.563
8	0.547
9	0.530
10	0.513
11	0.496



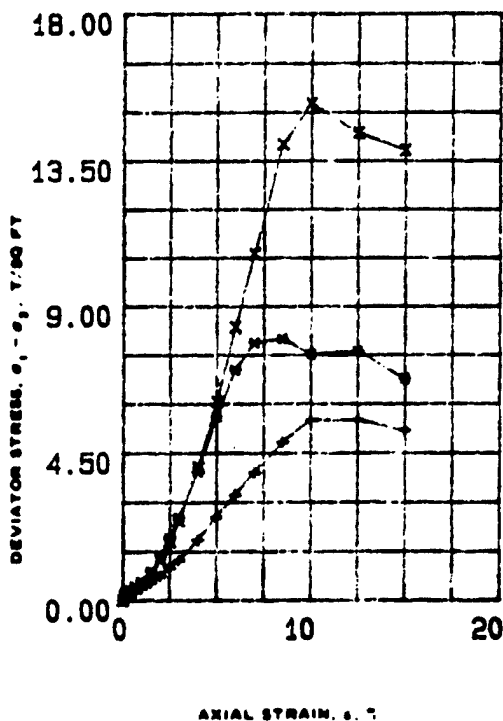
Q-1



Q-2



Q-3



NORMAL STRESS,  $P$ , T/50 FT

SPECIMEN NO.		1 (4)	2 (H)	3 (X)
INITIAL	WATER CONTENT, %	$w_p$ 24.8	23.0	22.2
	SOIL DENSITY LB/CU FT	$\gamma_d$ 103.1	107.0	109.1
	SATURATION, %	$s_e$ 100.0	100.0	100.0
	VOID RATIO	$e_p$ 0.64	0.58	0.55
BEFORE SHEAR	WATER CONTENT, %	$w_s$ 25.0	23.0	22.2
	SOIL DENSITY LB/CU FT	$\gamma_d$ 103.1	107.0	109.1
	SATURATION, %	$s_e$ 100.0	100.0	100.0
	VOID RATIO	$e_s$ 0.64	0.58	0.55
FINAL BACK PRESSURE, T/50 FT		$u_0$ 0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		$\sigma_3$ 1.0	2.0	4.0
MAXIMUM DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{max}$ 8.51	8.00	15.28
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		$t_1$ 24.3	20.0	25.3
ULTIMATE DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{ult}$ 8.17	8.75	13.82
INITIAL DIAMETER, IN.		$D_0$ 1.40	1.40	1.40
INITIAL HEIGHT, IN.		$H_0$ 2.88	2.88	2.88

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS Clayey Silt CL-ML

LL 27 PL 20  $P_i$  7  $G_c$  2.71

TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST Q

REMARKS: Mottled gray, rust. Torvane  
0.45 TSF. Slightly calcareous.

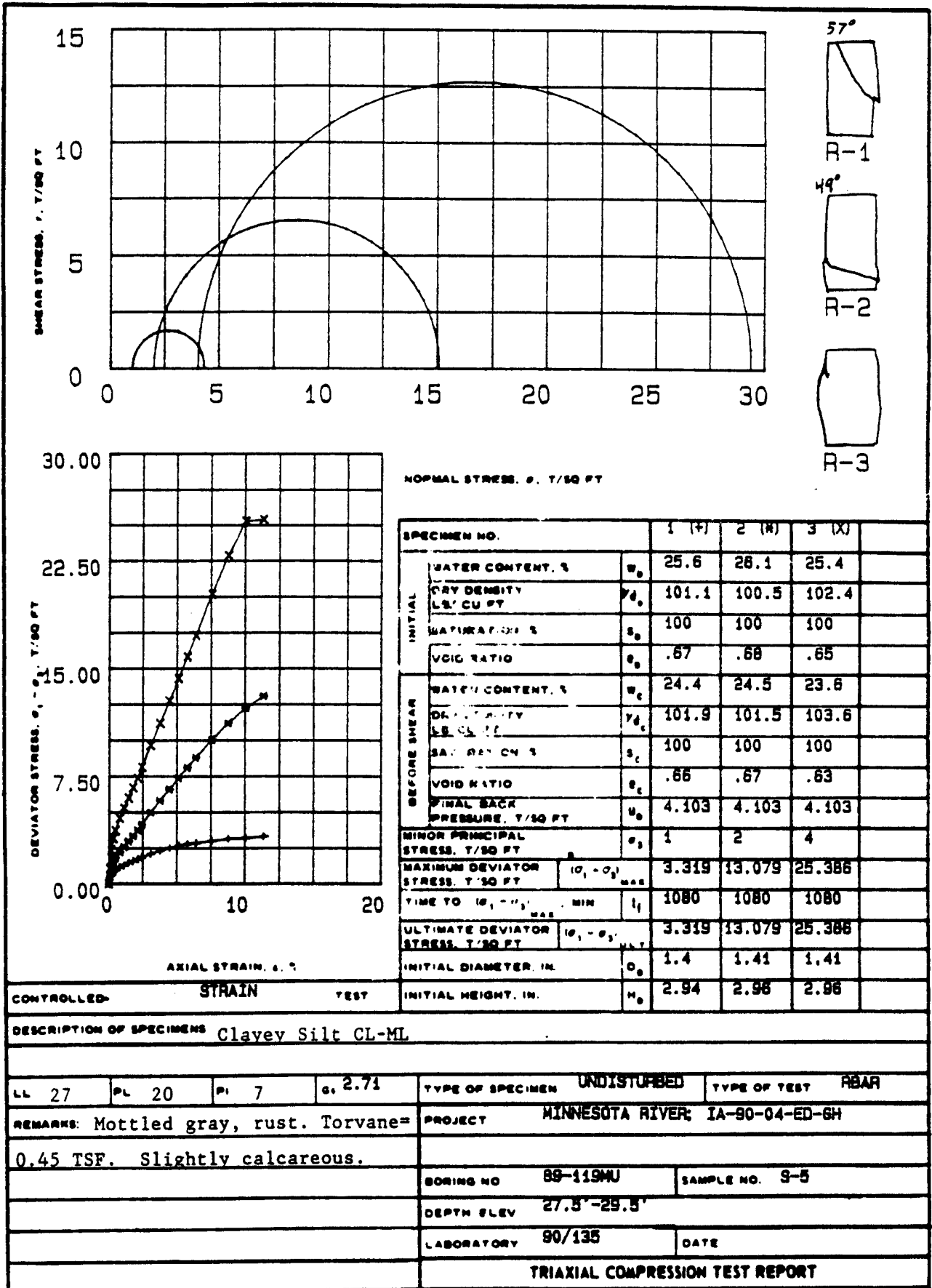
PROJECT MINNESOTA RIVER IA-90-04-ED-6H

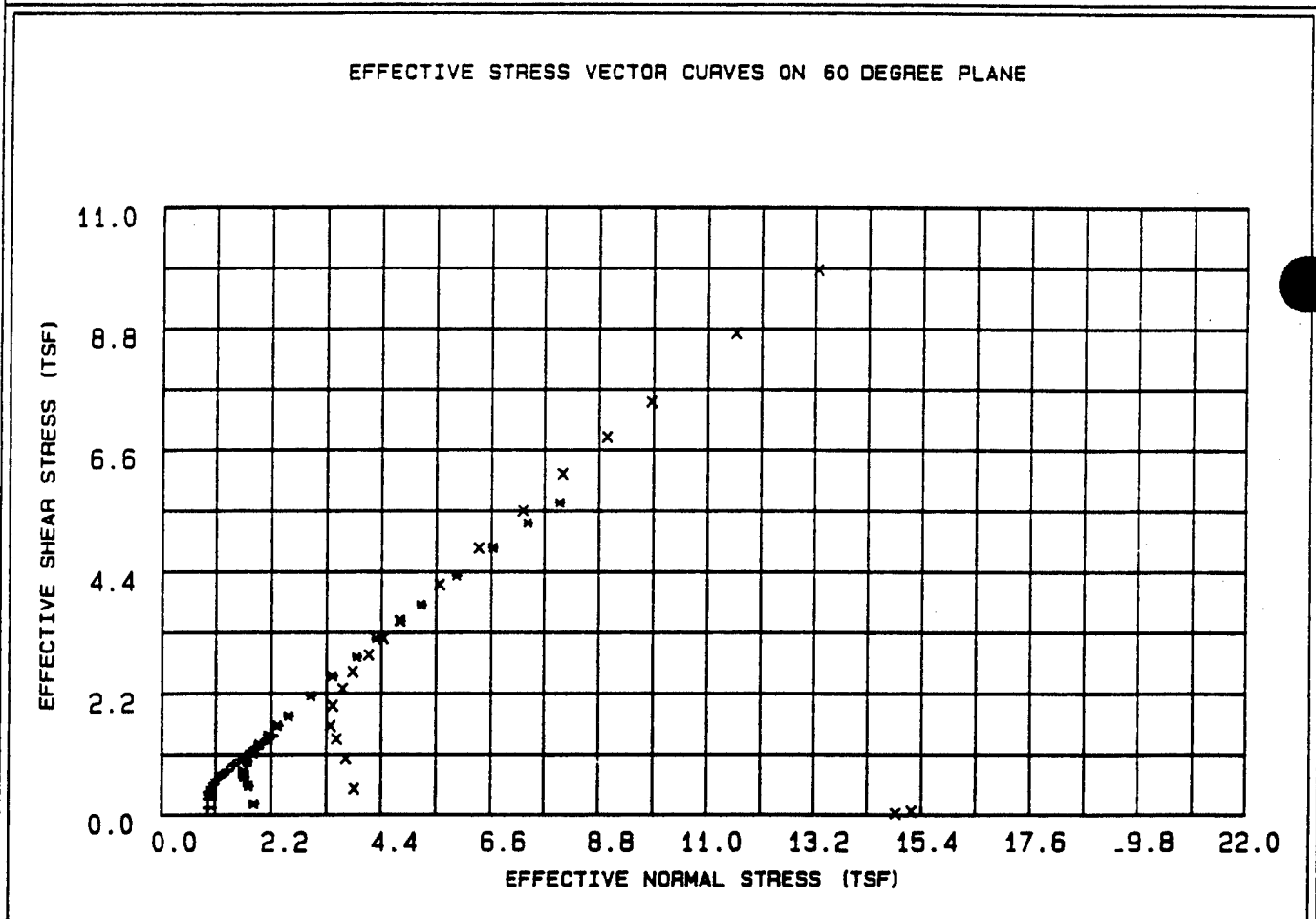
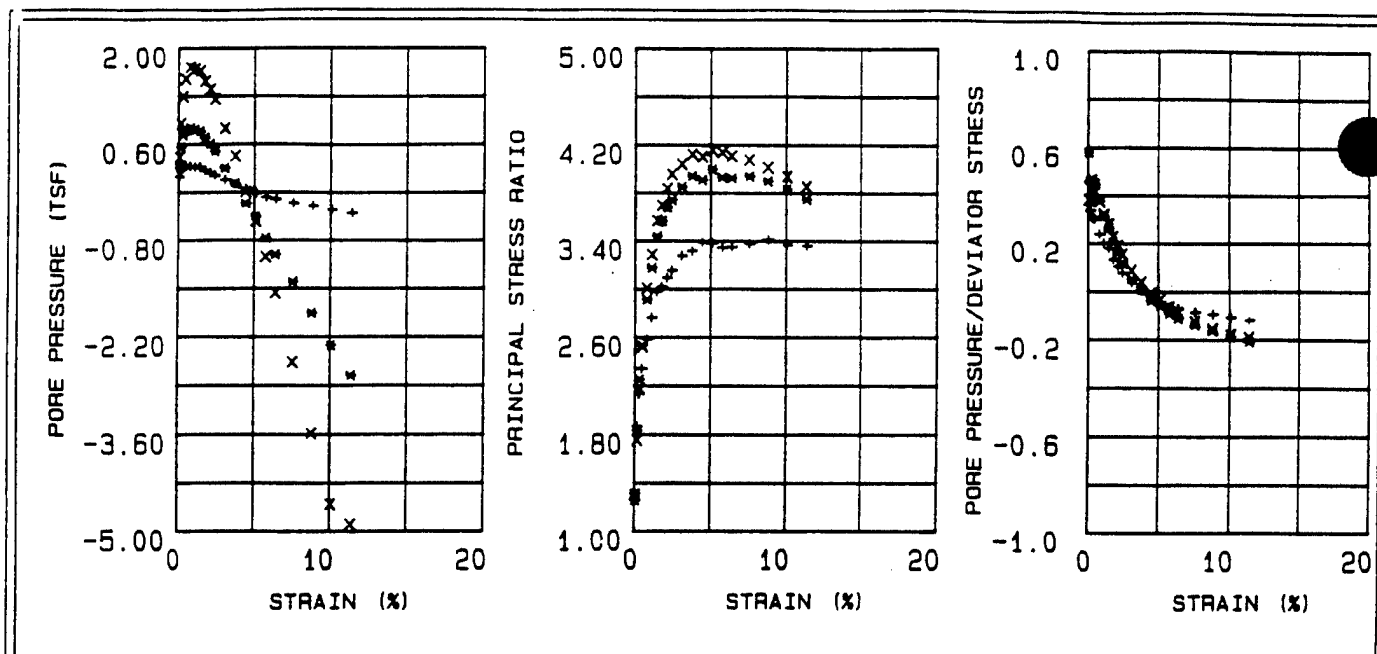
BORING NO 89-119 MU SAMPLE NO. S-5

DEPTH ELEV 27.5'-29.5'

LABORATORY 90/135 DATE

TRIAXIAL COMPRESSION TEST REPORT





<p>LEGEND</p> <p>+ = 1 TSF</p> <p>* = 2 TSF</p> <p>x = 4 TSF</p>		<p>PROJECT MINNESOTA RIVER: IA-90-04-ED-GH</p>	
<p>BORING NO. 89-119MU</p>		<p>SAMPLE NO. S-5</p>	
<p>DEPTH/ELEV 27.5'-29.5'</p>		<p>MRO LAB NO. 90/135</p>	

FIGURE 7

Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119MU  
 Sample Number : S-5  
 Depth : 27.5'-29.5'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.272	0.123	1.311	0.453	0.944	0.118
30	0.19	0.670	0.225	1.864	0.336	0.941	0.289
45	0.34	0.844	0.257	2.136	0.305	0.952	0.364
60	0.51	0.956	0.286	2.339	0.299	0.951	0.413
90	0.83	1.153	0.271	2.582	0.236	1.014	0.498
120	1.14	1.304	0.260	2.761	0.200	1.063	0.563
150	1.48	1.463	0.260	2.976	0.178	1.102	0.631
180	1.80	1.595	0.209	3.016	0.131	1.186	0.688
210	2.14	1.725	0.175	3.092	0.102	1.252	0.745
240	2.45	1.855	0.138	3.152	0.075	1.321	0.801
300	3.11	2.103	0.075	3.275	0.036	1.446	0.908
360	3.79	2.321	-0.003	3.315	-0.001	1.578	1.002
420	4.47	2.511	-0.054	3.383	-0.021	1.676	1.084
480	5.13	2.672	-0.123	3.379	-0.046	1.785	1.153
540	5.78	2.773	-0.184	3.342	-0.066	1.871	1.197
600	6.41	2.840	-0.210	3.347	-0.074	1.913	1.226
720	7.58	3.015	-0.270	3.375	-0.089	2.016	1.301
840	8.82	3.149	-0.307	3.409	-0.097	2.087	1.359
960	10.08	3.213	-0.358	3.366	-0.111	2.153	1.387
1080	11.39	3.319	-0.408	3.358	-0.122	2.230	1.432

Table 2 - Triaxial  $\bar{R}$  Test Results

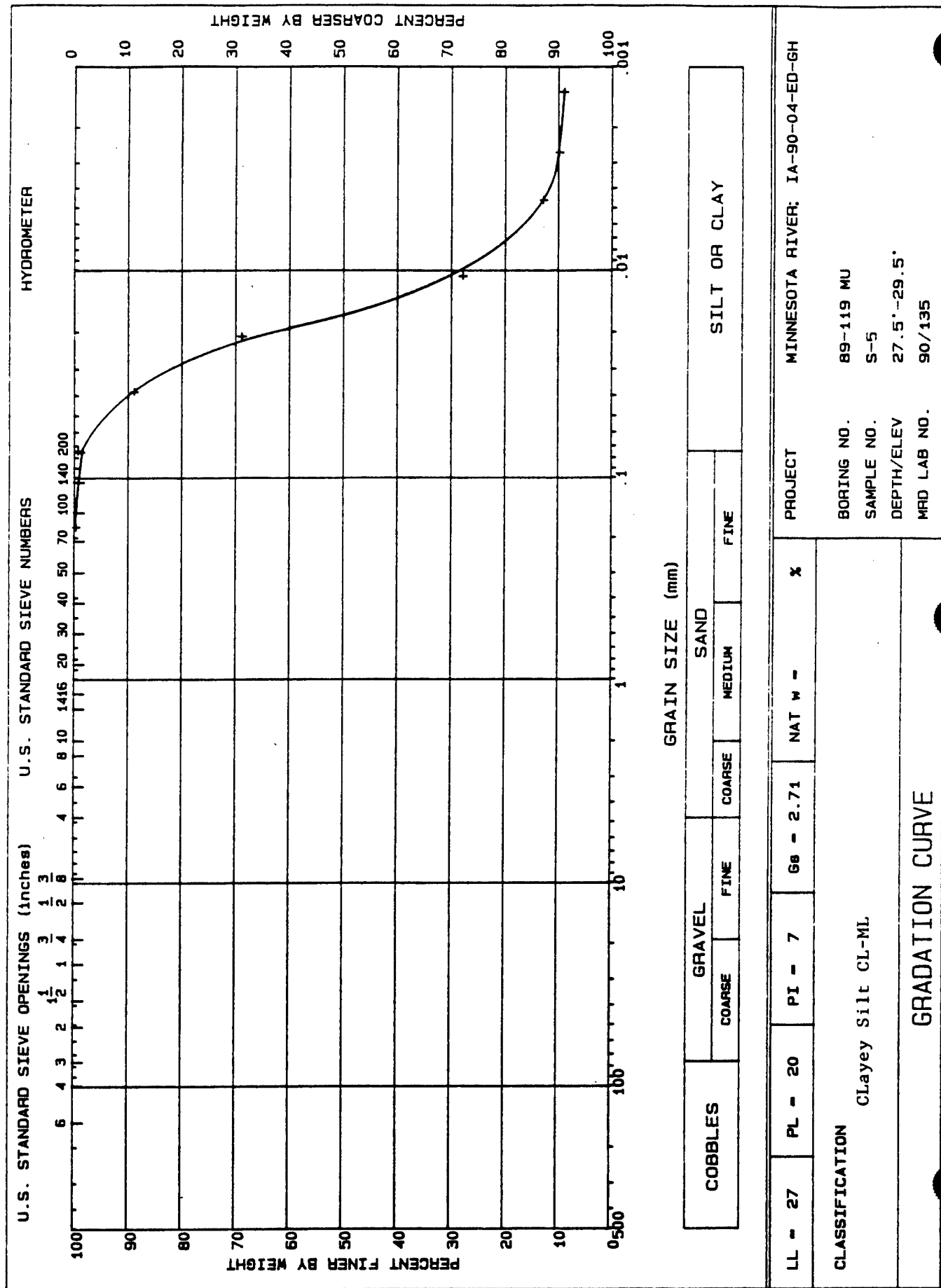
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119MU  
 Sample Number : S-5  
 Depth : 27.5'-29.5'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	0.444	0.258	1.255	0.580	1.852	0.192
30	0.19	1.202	0.555	1.832	0.462	1.743	0.519
45	0.34	1.579	0.736	2.249	0.467	1.655	0.681
60	0.51	1.820	0.811	2.532	0.446	1.640	0.786
90	0.83	2.227	0.834	2.910	0.375	1.717	0.961
120	1.14	2.593	0.807	3.174	0.312	1.835	1.119
150	1.48	2.975	0.779	3.436	0.262	1.958	1.284
180	1.79	3.355	0.690	3.562	0.206	2.141	1.448
210	2.13	3.750	0.599	3.677	0.160	2.329	1.618
240	2.44	4.143	0.488	3.741	0.118	2.538	1.788
300	3.10	4.994	0.248	3.850	0.050	2.989	2.156
360	3.78	5.814	0.023	3.940	0.004	3.416	2.509
420	4.46	6.603	-0.272	3.906	-0.041	3.907	2.850
480	5.11	7.382	-0.464	3.996	-0.062	4.292	3.186
5	5.77	8.114	-0.773	3.926	-0.095	4.782	3.502
600	6.39	8.802	-1.014	3.921	-0.115	5.193	3.799
720	7.56	10.036	-1.416	3.938	-0.141	5.901	4.332
840	8.79	11.192	-1.866	3.895	-0.166	6.637	4.830
960	10.05	12.240	-2.329	3.828	-0.190	7.359	5.283
1080	11.36	13.079	-2.766	3.744	-0.211	8.004	5.645

Table 1 - Triaxial  $\bar{R}$  Test Results

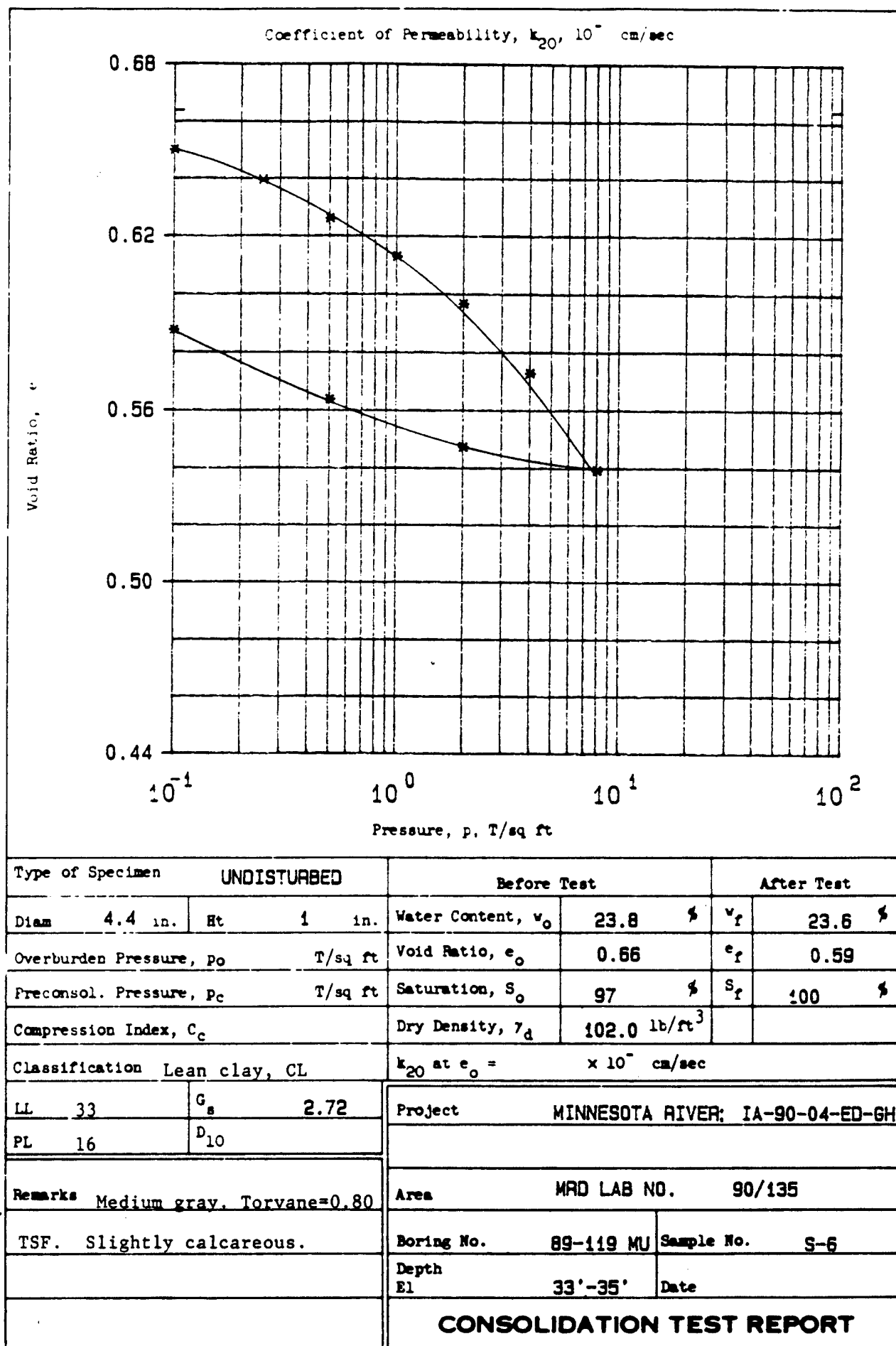
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119MU  
 Sample Number : S-5  
 Depth : 27.5'-29.5'  
 Confining Pressure : 4 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.07	1.079	0.410	1.301	0.380	3.857	0.466
30	0.19	2.342	0.896	1.754	0.383	3.684	1.011
45	0.34	3.185	1.288	2.174	0.405	3.500	1.374
60	0.51	3.730	1.546	2.520	0.415	3.378	1.610
90	0.82	4.576	1.715	3.003	0.375	3.418	1.975
120	1.14	5.280	1.689	3.284	0.320	3.618	2.279
150	1.48	5.994	1.662	3.564	0.278	3.822	2.587
180	1.79	6.705	1.510	3.693	0.226	4.150	2.894
210	2.13	7.392	1.390	3.832	0.189	4.440	3.191
240	2.44	8.128	1.248	3.953	0.154	4.764	3.508
300	3.10	9.648	0.824	4.038	0.086	5.565	4.164
360	3.78	11.178	0.419	4.121	0.038	6.348	4.825
420	4.45	12.735	-0.107	4.101	-0.008	7.260	5.497
480	5.11	14.289	-0.526	4.157	-0.036	8.064	6.167
540	5.76	15.820	-1.047	4.135	-0.066	8.964	6.828
600	6.39	17.302	-1.573	4.105	-0.090	9.856	7.467
720	7.55	20.189	-2.571	4.073	-0.127	11.569	8.714
840	8.79	22.869	-3.596	4.011	-0.157	13.258	9.870
960	10.05	25.289	-4.616	3.935	-0.182	14.877	10.915
1080	11.35	25.386	-4.910	3.849	-0.193	15.195	10.957



LL - 27	PL - 20	PI - 7	Gs - 2.71	NAT w -	%	PROJECT	MINNESOTA RIVER: IA-90-04-ED-GH
<b>CLASSIFICATION</b> Clayey Silt CL-ML <b>GRADATION CURVE</b>						BORING NO.	89-119 MU
						SAMPLE NO.	S-5
						DEPTH/ELEV	27.5'-29.5'
						MRD LAB NO.	90/135





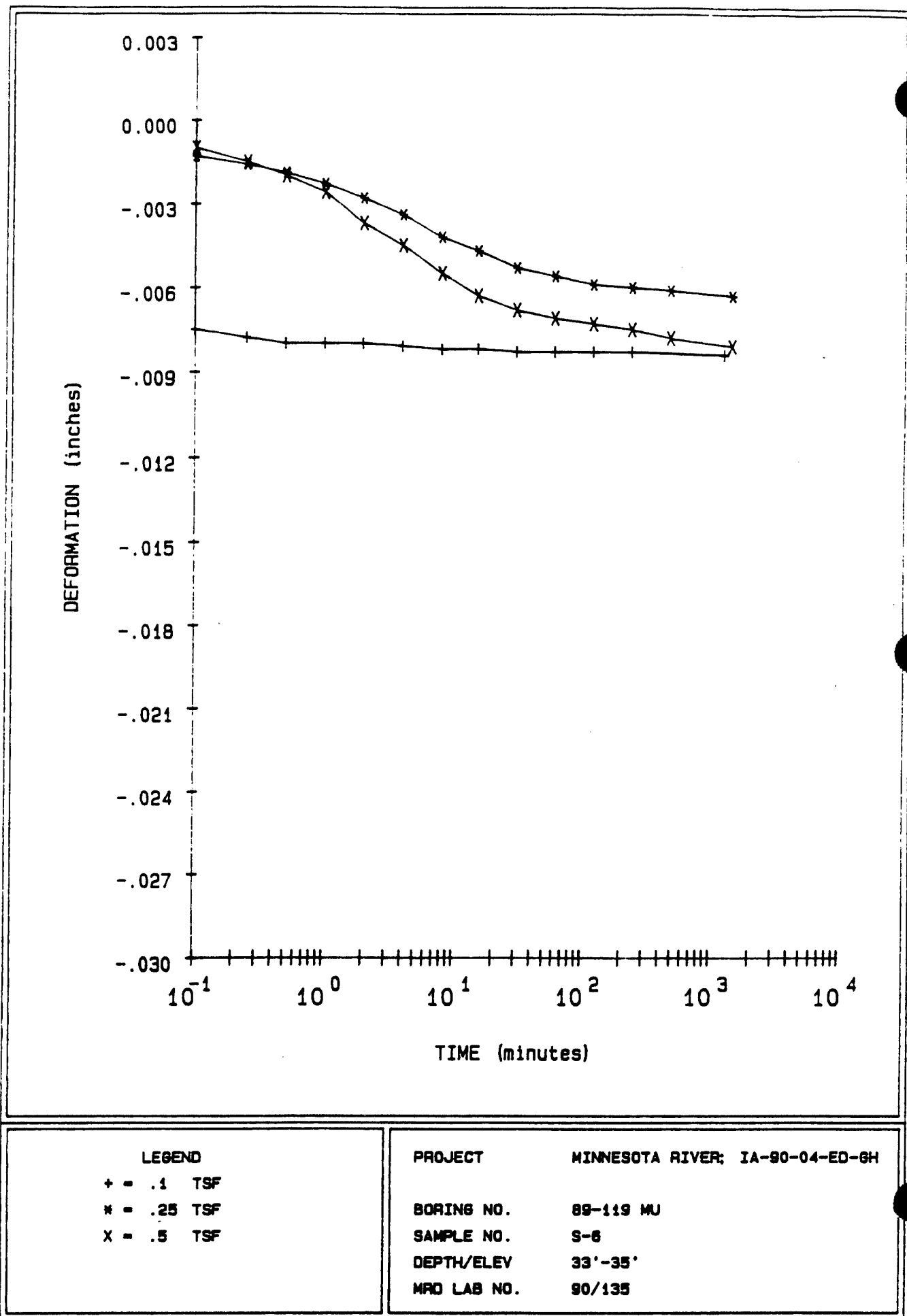
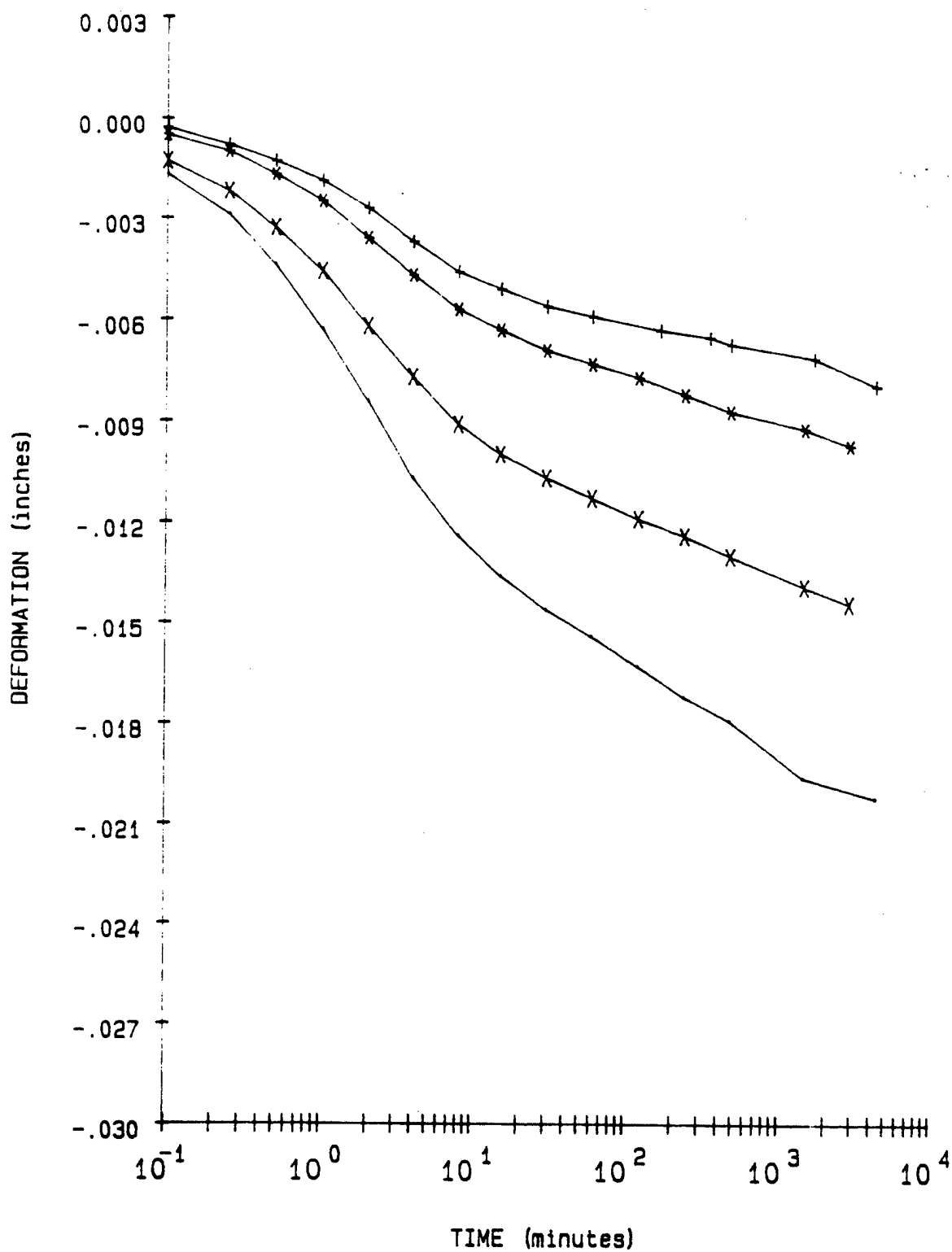


FIGURE 10



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-6H

BORING NO.

89-119 MU

SAMPLE NO.

S-6

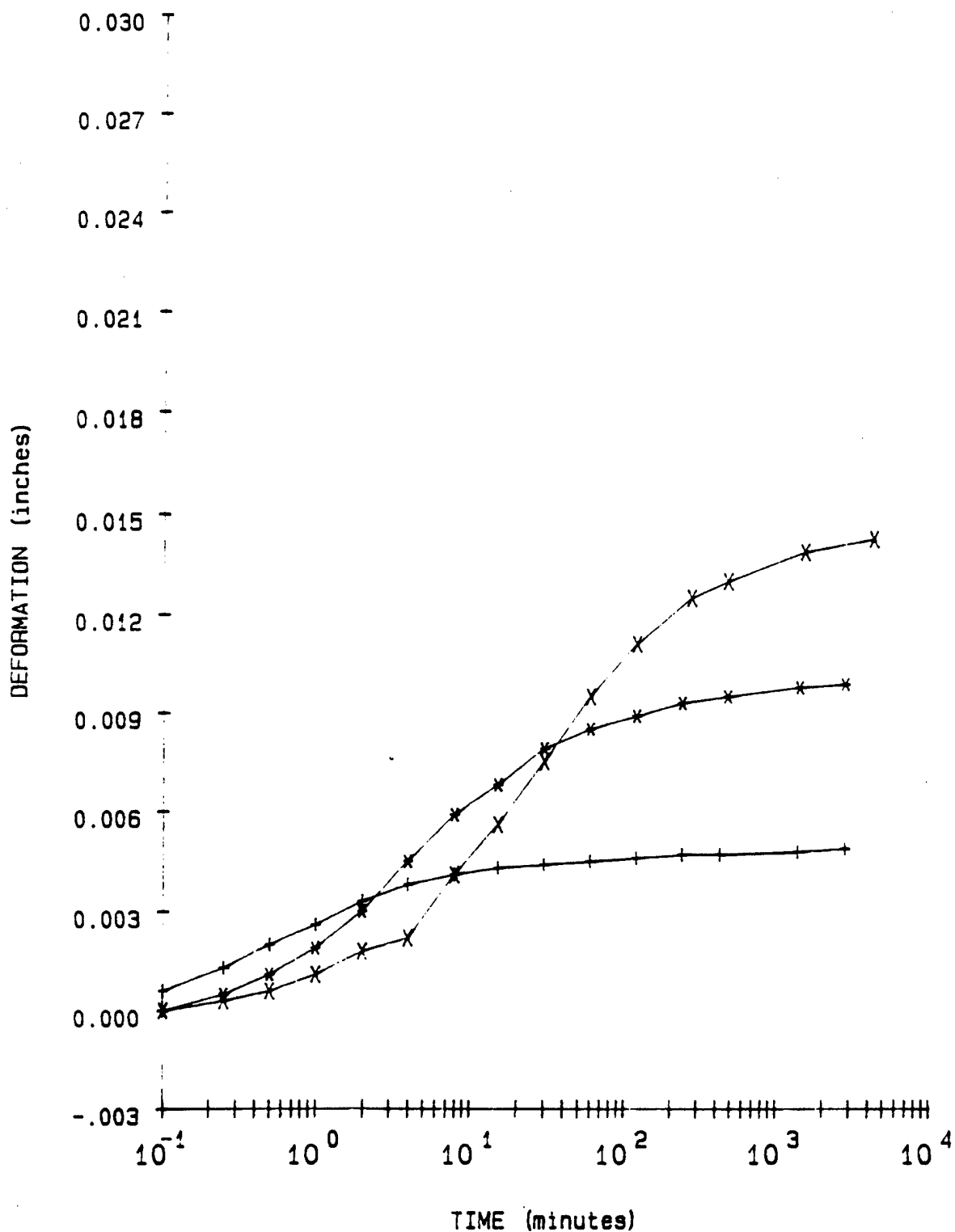
DEPTH/ELEV

33'-35'

MRD LAB NO.

90/135

FIGURE 11



LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO.

89-119 MU

SAMPLE NO.

S-6

DEPTH/ELEV

33'-35'

MRO LAB NO.

90/135

FIGURE 12

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-119 MU

Sample No. S-6

Depth/Elev 33'-35'

MRD Lab No. 90/135

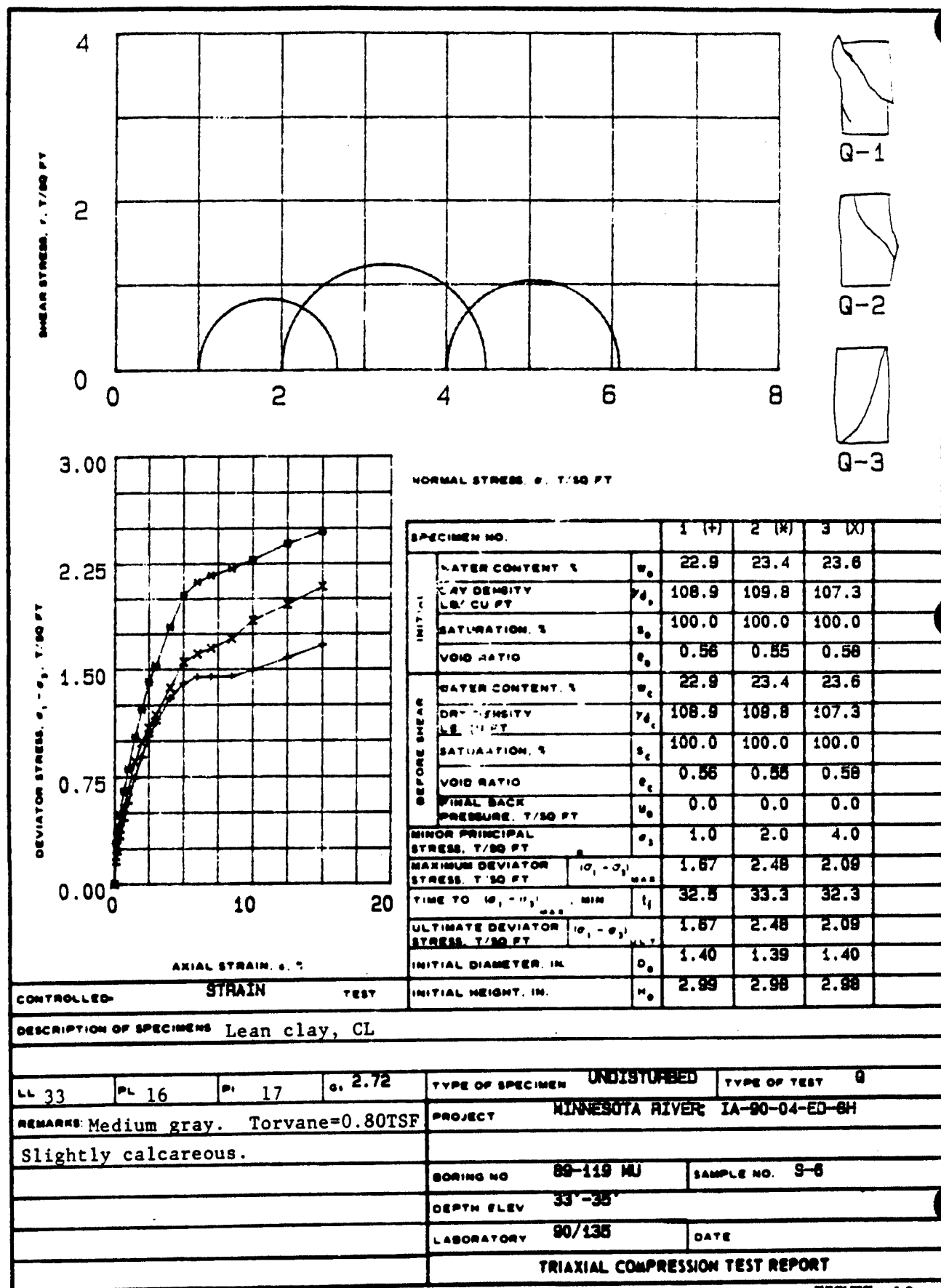
Gs = 2.72

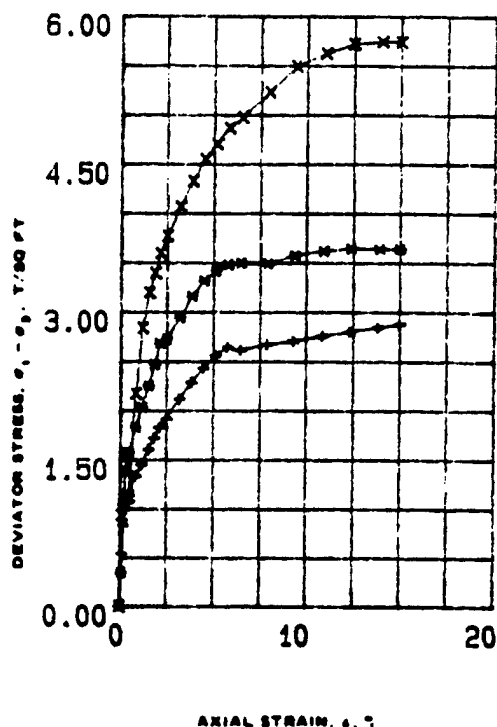
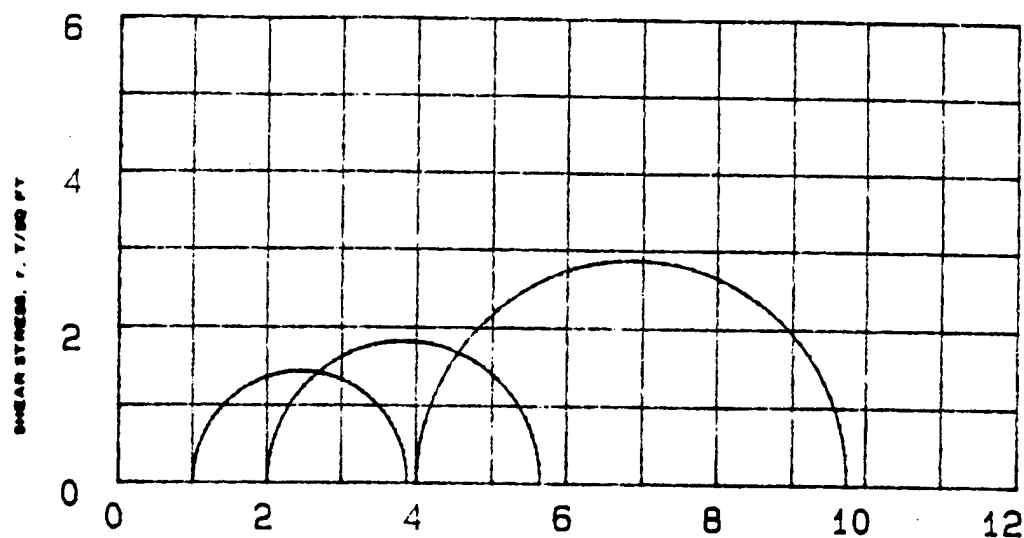
eo = 0.664

0.42eo = 0.279

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
23.8	414.4	102.0	0.664		97.3
23.6	414.4	102.9	0.650	0.10	98.9
23.6	414.4	103.5	0.639	0.25	100.0
23.6	414.4	104.4	0.626	0.50	100.0
23.6	414.4	105.2	0.613	1.00	100.0
23.6	414.4	106.3	0.597	2.00	100.0
23.6	414.4	107.9	0.573	4.00	100.0
3.6	414.4	110.3	0.539	8.00	100.0
23.6	414.4	109.7	0.547	2.00	100.0
23.6	414.4	108.5	0.564	0.50	100.0
23.6	414.4	106.9	0.588	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.647
2	0.631
3	0.614
4	0.597
5	0.581
6	0.564
7	0.547
8	0.531
9	0.514
10	0.498





NORMAL STRESS,  $\sigma$ , T/SQ FT

SPECIMEN NO.		1 (+)	2 (H)	3 (X)
INITIAL	WATER CONTENT, %	23.4	24.2	23.7
	DRY DENSITY LB/ CU FT	103.5	102.9	103.5
	SATURATION, %	100	100	100
	VOID RATIO	.84	.85	.84
BEFORE SHEAR	WATER CONTENT, %	23	23.3	20.6
	DR. DENSITY LB/ CU FT	104.6	105.9	108.9
	SATURATION, %	100	100	100
	VOID RATIO	.82	.8	.56
FINAL BACK PRESSURE, T/SQ FT		5.543	5.543	5.543
MINOR PRINCIPAL STRESS, T/SQ FT		1	2	4
MAXIMUM DEVIATOR STRESS, T/SQ FT		2.876	3.650	5.746
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$ , MIN		1299	1080	1200
ULTIMATE DEVIATOR STRESS, T/SQ FT		2.876	3.843	5.741
INITIAL DIAMETER, IN.		1.4	1.4	1.4
INITIAL HEIGHT, IN.		2.99	2.99	2.99

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS Lean clay, CL B-Value 1.0 1.0 1.0

LL 33 PL 16 P<sub>i</sub> 17 G<sub>s</sub> 2.72

TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST FBAR

REMARKS: Medium gray. Torvane=0.80TSB PROJECT MINNESOTA RIVER IA-90-04-ED-0H

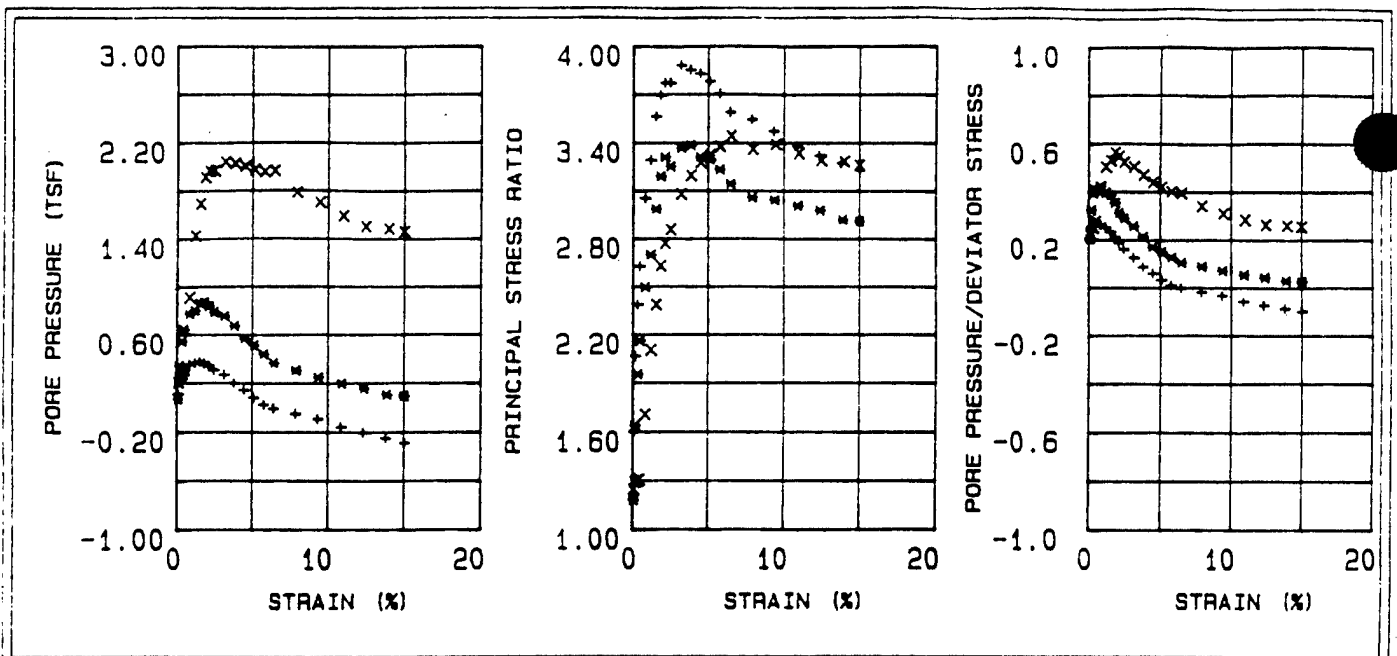
Slightly calcareous.

BORING NO 88-119 MJ SAMPLE NO. 9-8

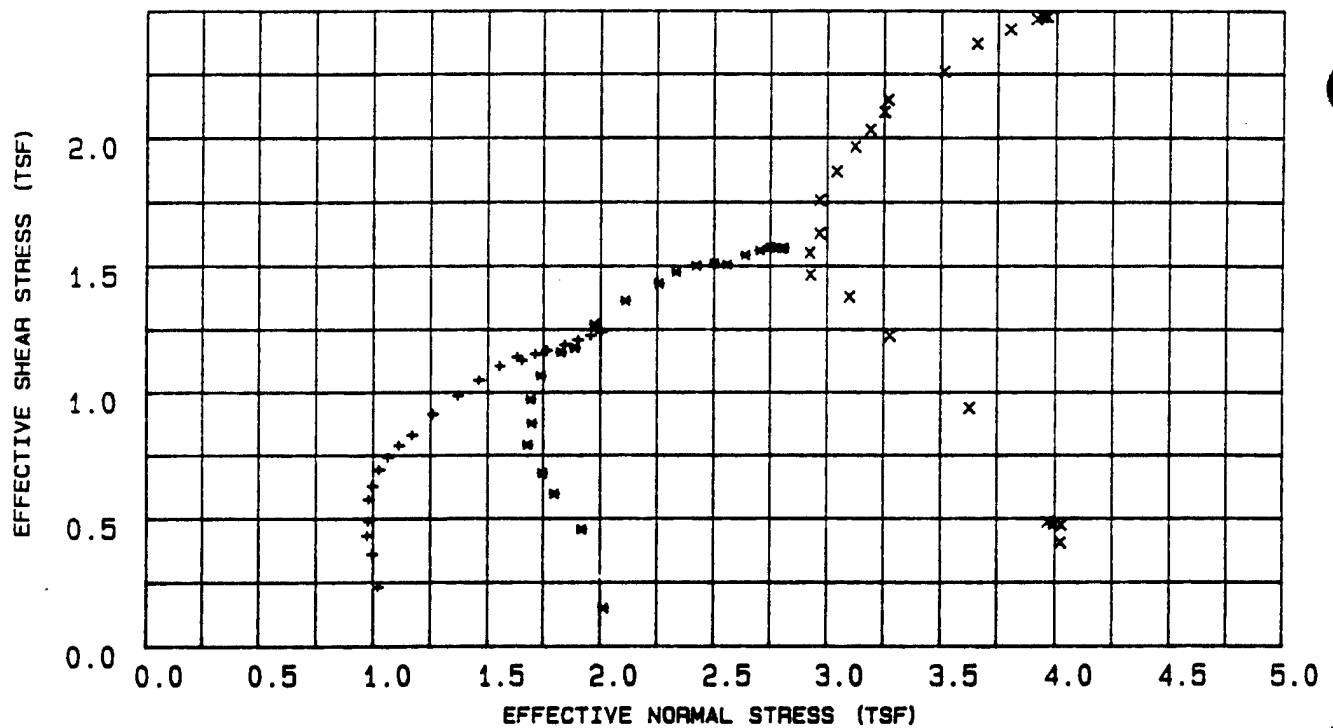
DEPTH ELEV 33'-38'

LABORATORY 90/135 DATE

TRIAXIAL COMPRESSION TEST REPORT



EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO.

89-119 MU

SAMPLE NO.

S-6

DEPTH/ELEV

33'-35'

MRD LAB NO.

90/135



Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-6  
 Depth : 33'-35'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.535	0.109	1.601	0.204	1.024	0.231
30	0.19	0.837	0.213	2.064	0.255	0.994	0.361
45	0.34	1.004	0.277	2.388	0.276	0.972	0.433
60	0.48	1.135	0.302	2.627	0.267	0.979	0.490
90	0.83	1.332	0.351	3.051	0.264	0.979	0.575
120	1.19	1.456	0.365	3.292	0.251	0.995	0.628
150	1.53	1.607	0.373	3.564	0.233	1.025	0.693
180	1.84	1.721	0.362	3.697	0.211	1.064	0.743
210	2.12	1.828	0.341	3.774	0.187	1.111	0.789
240	2.48	1.922	0.307	3.773	0.160	1.169	0.830
300	3.17	2.119	0.266	3.886	0.126	1.259	0.914
360	3.81	2.288	0.198	3.853	0.087	1.368	0.987
420	4.46	2.429	0.141	3.828	0.059	1.460	1.048
480	5.08	2.560	0.080	3.782	0.032	1.554	1.105
540	5.75	2.645	0.022	3.704	0.009	1.633	1.142
600	6.44	2.611	-0.009	3.589	-0.003	1.655	1.127
720	7.87	2.673	-0.051	3.544	-0.018	1.713	1.154
840	9.32	2.706	-0.095	3.472	-0.034	1.765	1.168
960	10.85	2.758	-0.160	3.377	-0.058	1.843	1.190
1080	12.30	2.801	-0.208	3.319	-0.074	1.901	1.209
1200	13.80	2.846	-0.252	3.274	-0.088	1.957	1.228
1298	15.00	2.876	-0.291	3.229	-0.100	2.003	1.241

Table 5 - Triaxial  $\bar{R}$  Test Results

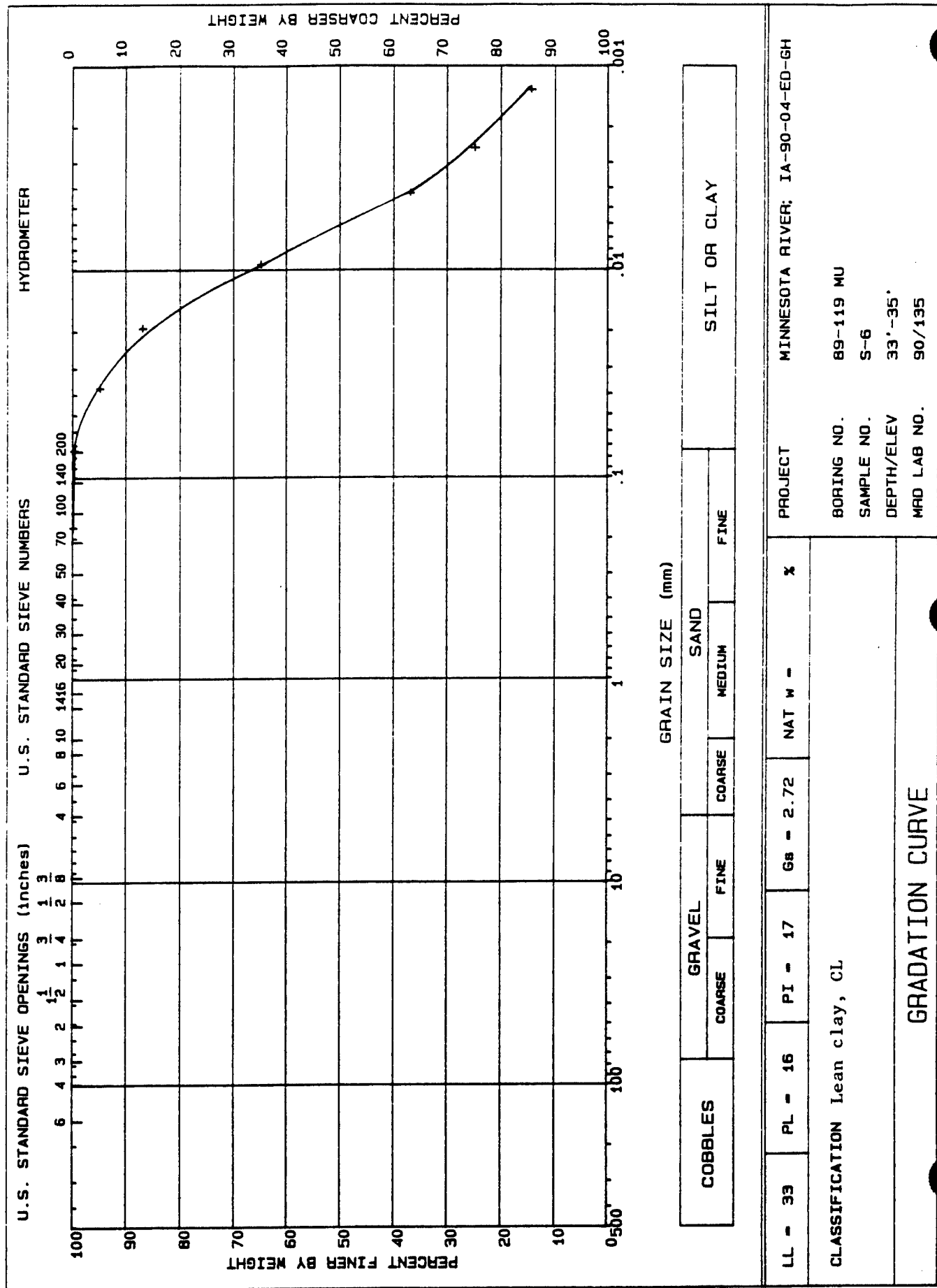
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-6  
 Depth : 33'-35'  
 Confining Pressure : 2 TSF

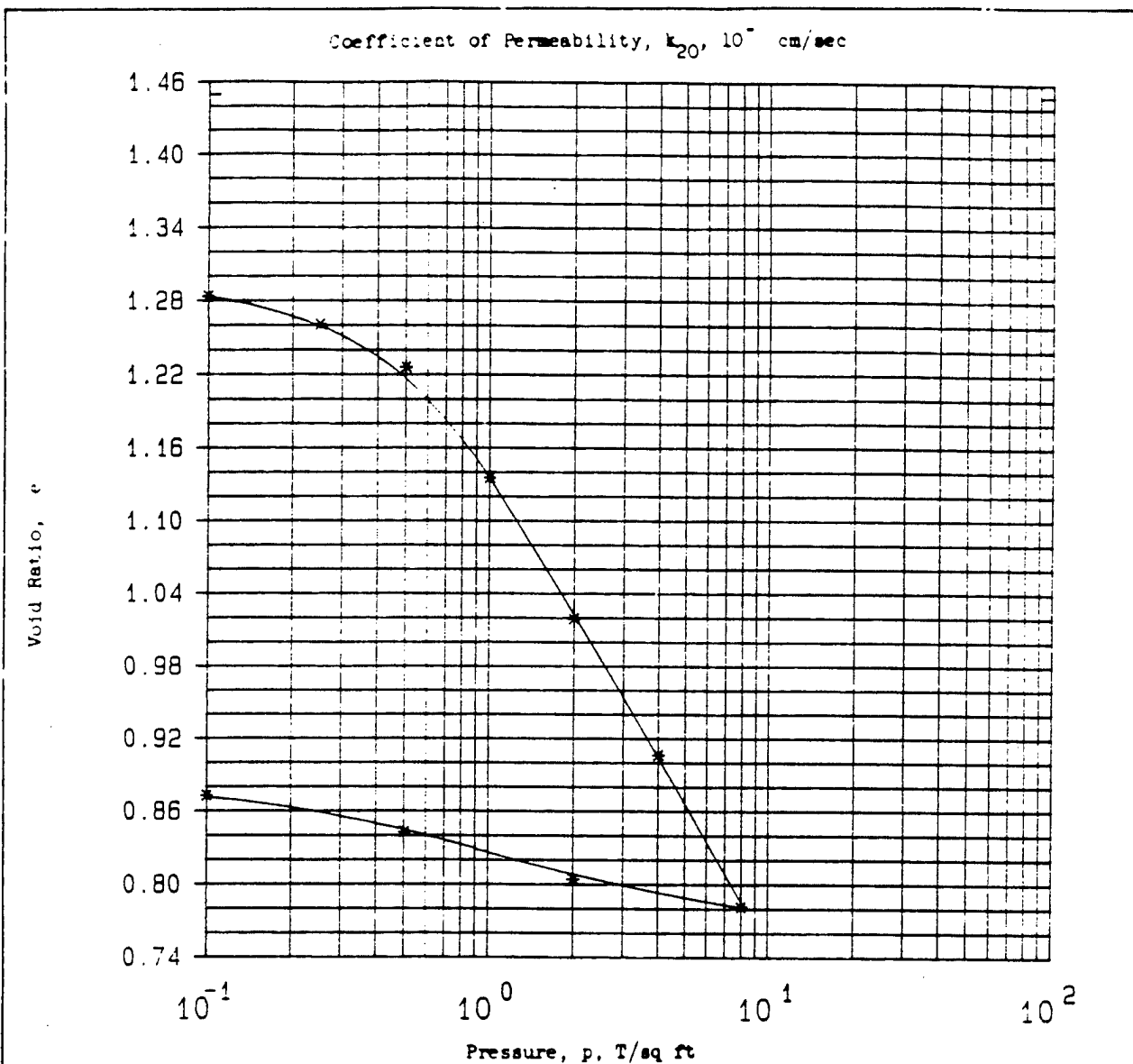
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.09	0.347	0.071	1.180	0.204	2.015	0.150
30	0.19	1.060	0.343	1.640	0.324	1.919	0.458
45	0.34	1.385	0.545	1.952	0.394	1.798	0.598
60	0.48	1.574	0.644	2.160	0.409	1.746	0.679
90	0.84	1.833	0.774	2.496	0.423	1.680	0.791
120	1.20	2.034	0.804	2.700	0.396	1.699	0.878
150	1.54	2.252	0.865	2.985	0.385	1.693	0.972
180	1.85	2.470	0.873	3.191	0.354	1.738	1.066
210	2.14	2.687	0.838	3.312	0.312	1.827	1.160
240	2.50	2.730	0.788	3.253	0.289	1.888	1.178
300	3.19	2.947	0.756	3.369	0.257	1.974	1.272
360	3.84	3.163	0.674	3.386	0.214	2.109	1.365
420	4.49	3.321	0.565	3.314	0.171	2.257	1.433
480	5.11	3.421	0.513	3.300	0.150	2.334	1.477
540	5.78	3.482	0.440	3.232	0.127	2.422	1.503
600	6.48	3.504	0.365	3.143	0.105	2.502	1.512
720	7.92	3.489	0.305	3.058	0.088	2.559	1.506
840	9.38	3.577	0.248	3.042	0.070	2.638	1.544
960	10.92	3.622	0.194	3.006	0.054	2.703	1.563
1080	12.38	<del>3.650</del>	0.154	2.977	0.043	2.750	1.575
1200	13.89	3.639	0.103	2.918	0.029	2.798	1.570
1290	15.00	3.643	0.093	2.910	0.026	2.809	1.572

Table 6 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-119 MU  
 Sample Number : S-6  
 Depth : 33'-35'  
 Confining Pressure : 4 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.937	0.207	1.247	0.221	4.025	0.405
30	0.19	1.097	0.244	1.292	0.223	4.028	0.474
45	0.34	1.112	0.279	1.299	0.251	3.996	0.480
60	0.48	1.127	0.311	1.306	0.277	3.968	0.486
90	0.85	2.174	0.911	1.704	0.419	3.627	0.938
120	1.21	2.839	1.426	2.103	0.503	3.277	1.225
150	1.55	3.199	1.693	2.387	0.530	3.099	1.381
180	1.86	3.398	1.915	2.629	0.564	2.926	1.466
210	2.15	3.597	1.968	2.770	0.548	2.922	1.552
240	2.51	3.773	1.968	2.857	0.522	2.966	1.628
300	3.21	4.070	2.043	3.080	0.503	2.965	1.757
360	3.87	4.331	2.029	3.197	0.469	3.043	1.869
420	4.52	4.553	2.003	3.280	0.440	3.124	1.965
480	5.15	4.705	1.975	3.324	0.420	3.190	2.031
5	5.82	4.869	1.954	3.379	0.402	3.251	2.101
600	6.52	4.977	1.964	3.444	0.395	3.268	2.148
720	7.97	5.234	1.784	3.362	0.341	3.512	2.259
840	9.45	5.494	1.703	3.392	0.310	3.657	2.371
960	10.99	5.625	1.589	3.333	0.283	3.804	2.428
1080	12.47	5.722	1.502	3.291	0.263	3.915	2.470
1200	13.99	5.746	<del>1.483</del>	3.283	0.259	3.940	2.480
1282	15.00	5.741	1.460	3.261	0.255	3.961	2.478





Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	1 in.	Water Content, $w_o$	54.0 %	$w_f$	34.5 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	1.45	$e_f$	0.87
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	99 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	67.8 lb/ft <sup>3</sup>		
Classification		Fat clay, CH		$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec			
LL	64	$G_s$	2.66	Project			
PL	49	$D_{10}$		MINNESOTA RIVER: IA-90-04-ED-GH			
Remarks Dark gray. Torvane=0.25TSR				Area			
Slightly calcareous organic.				MRD LAB NO. 90/135			
				Boring No. 89-126 MU		Sample No. S-1	
				Depth El 12'-14'		Date	
				<b>CONSOLIDATION TEST REPORT</b>			

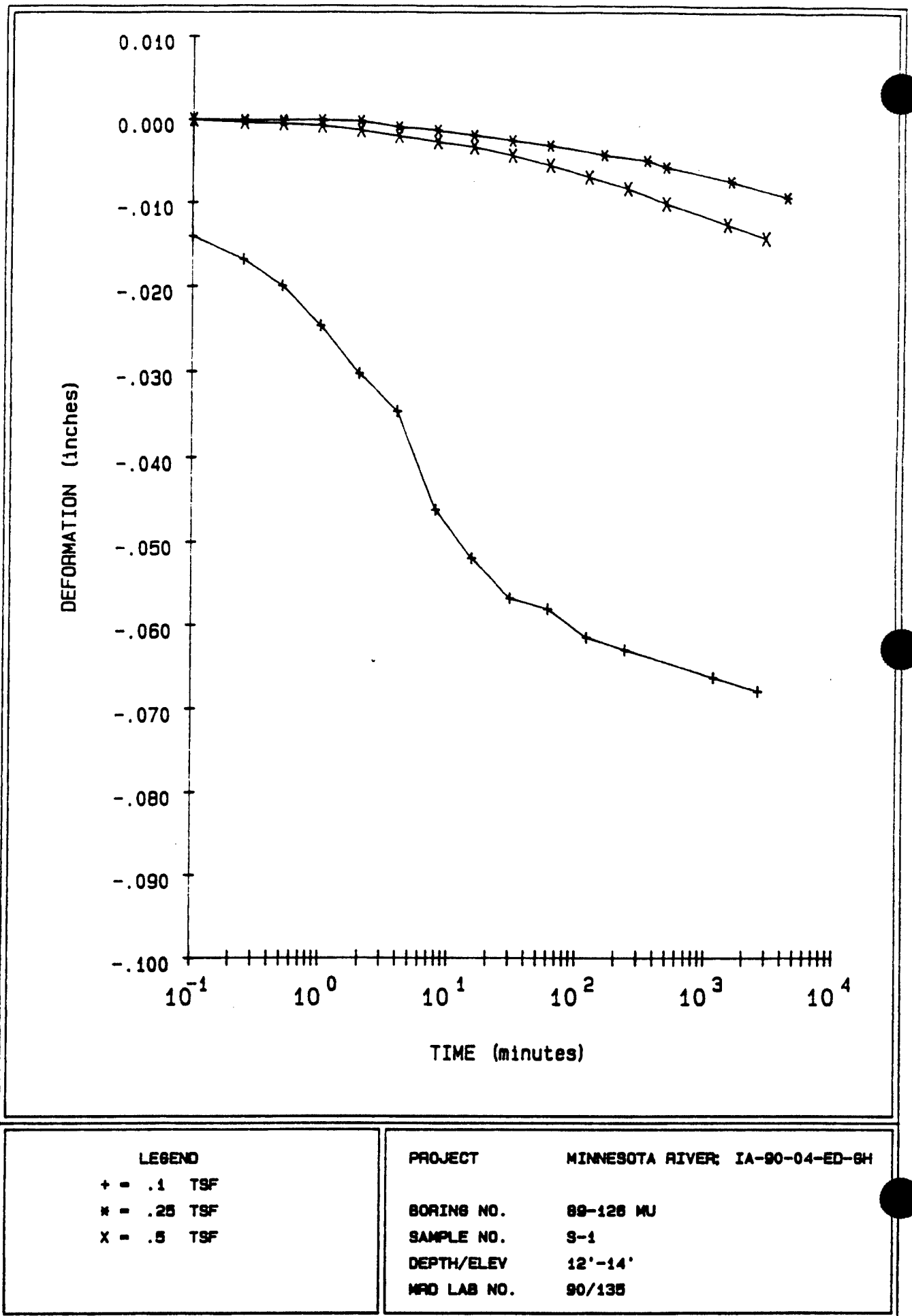
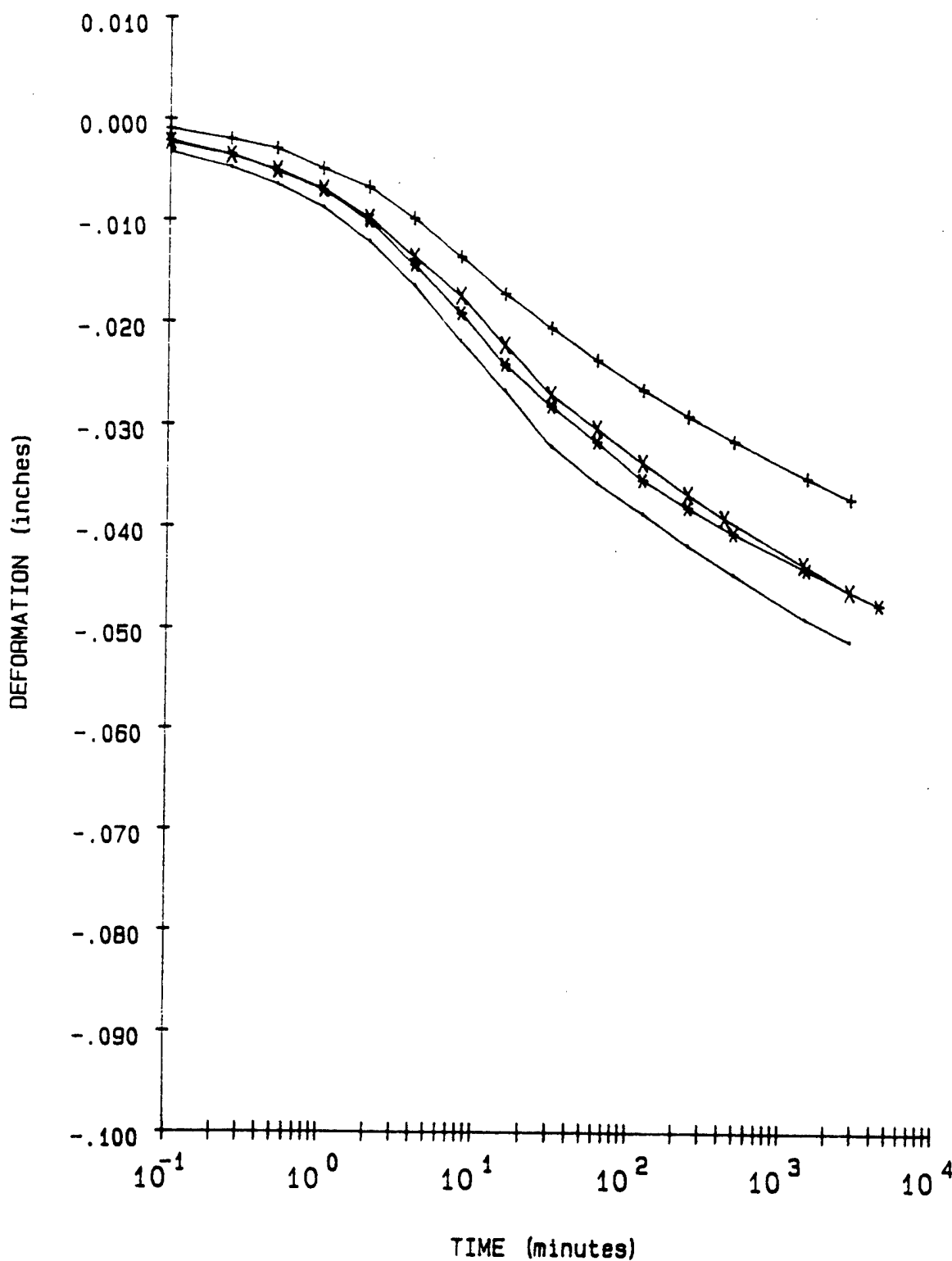


FIGURE 18



**LEGEND**

+ = 1 TSF  
 x = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

**PROJECT**

MINNESOTA RIVER; IA-90-04-ED-6H

BORING NO.

89-126 MU

SAMPLE NO.

S-1

DEPTH/ELEV

12'-14'

MFD LAB NO.

90/135

FIGURE 19

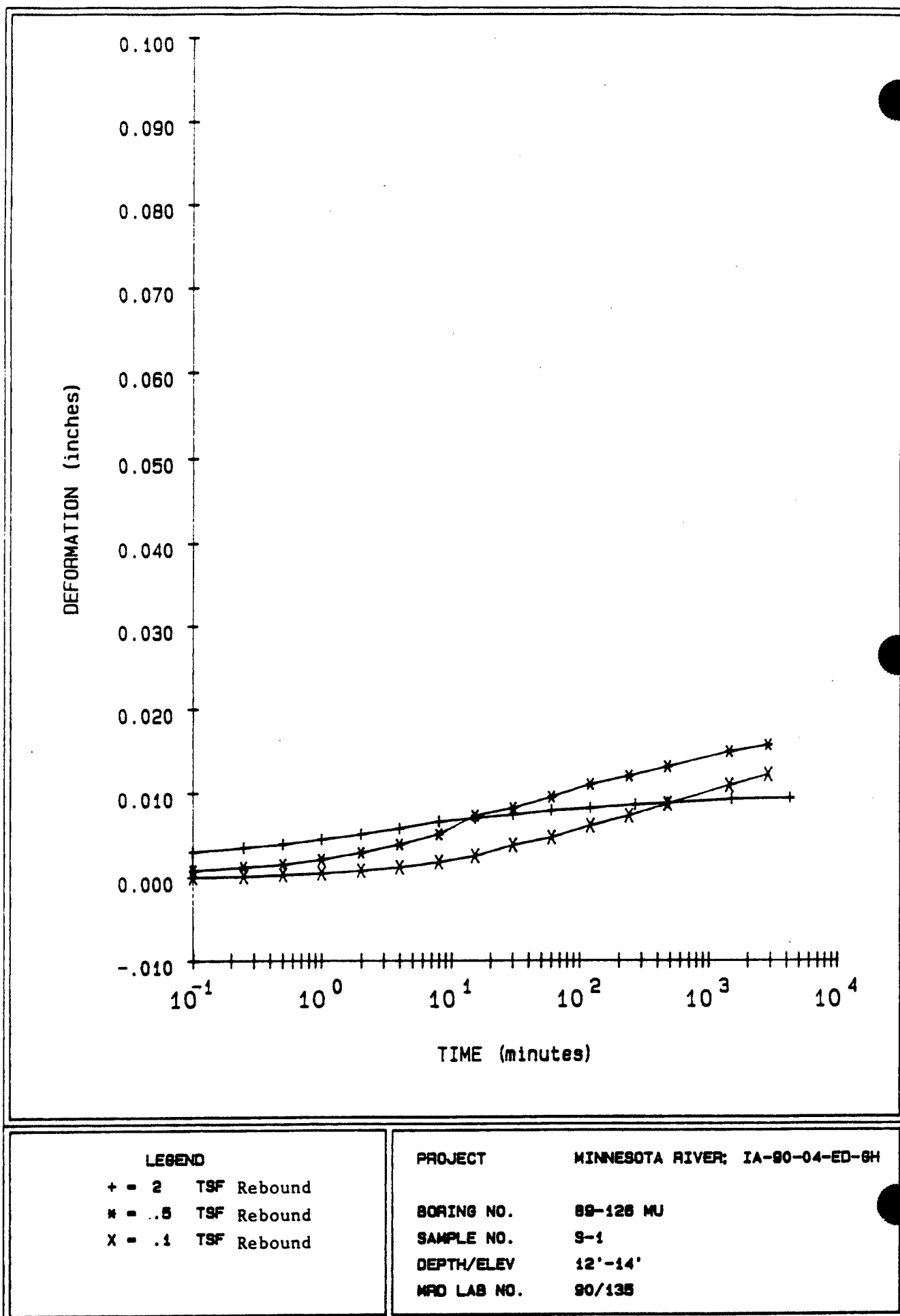


FIGURE 20



# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-126 MU

Sample No. S-1

Depth/Elev 12'-14'

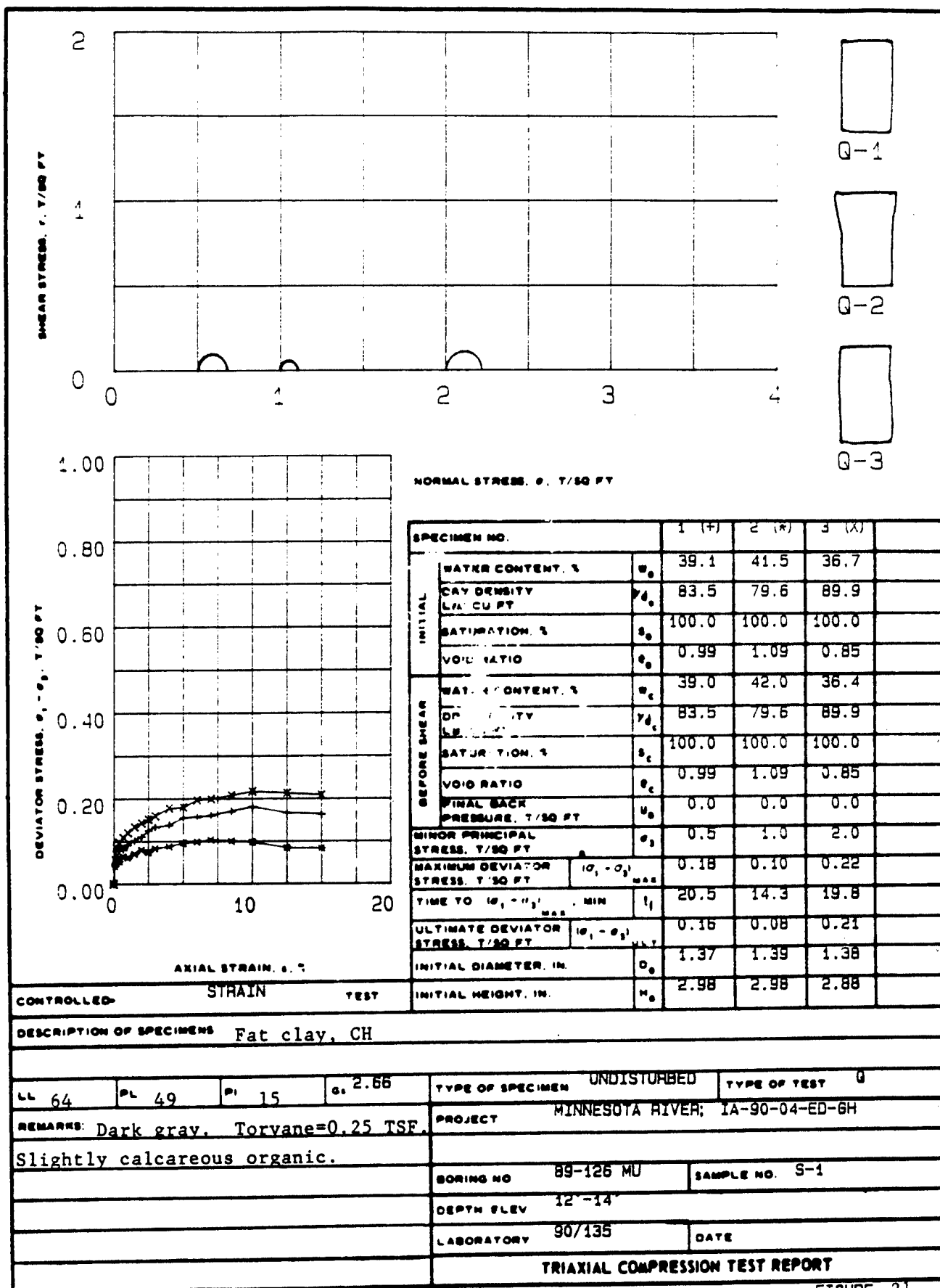
MRD Lab No. 90/135

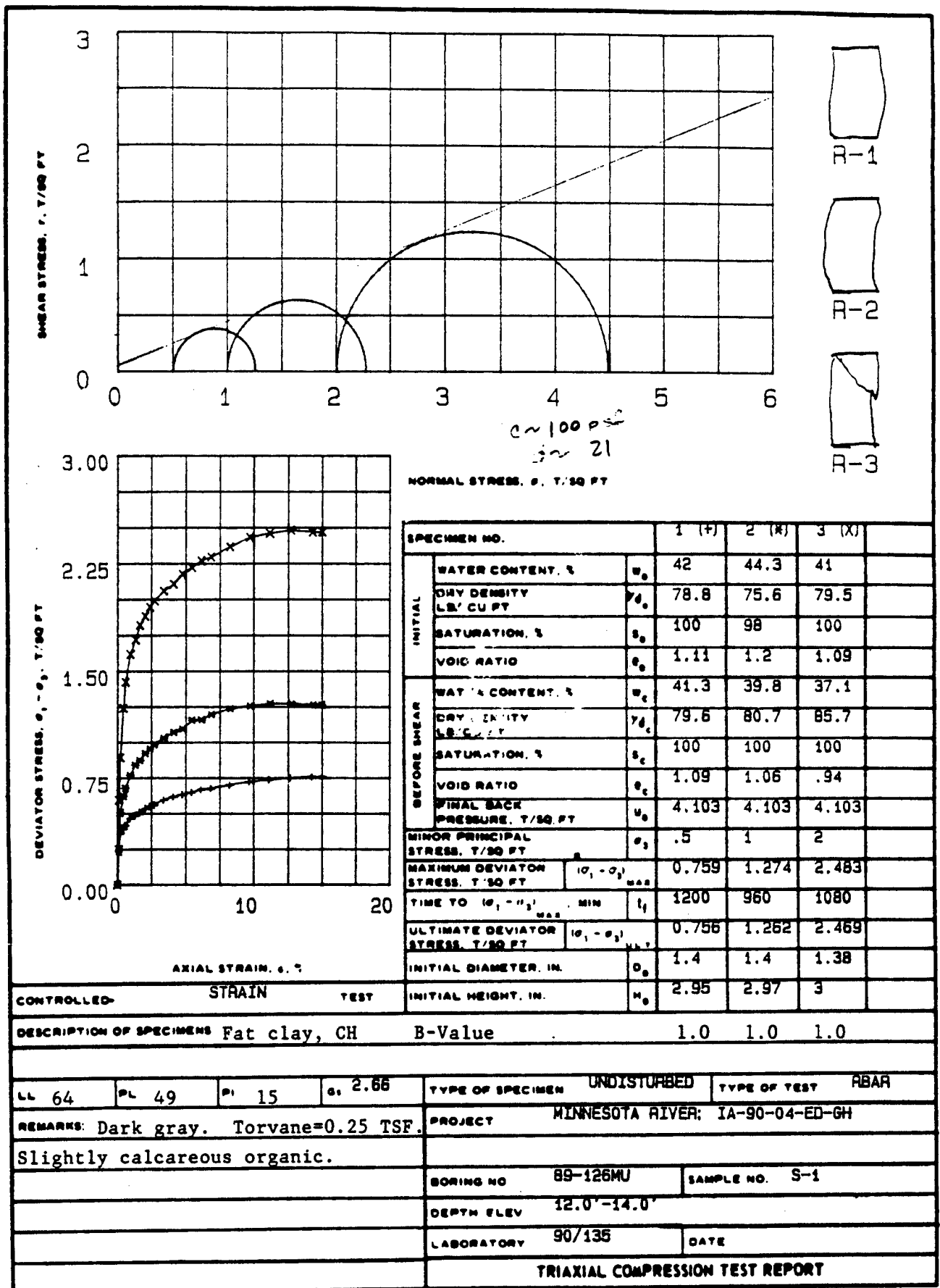
Gs = 2.66  
eo = 1.450  
0.42eo = 0.609

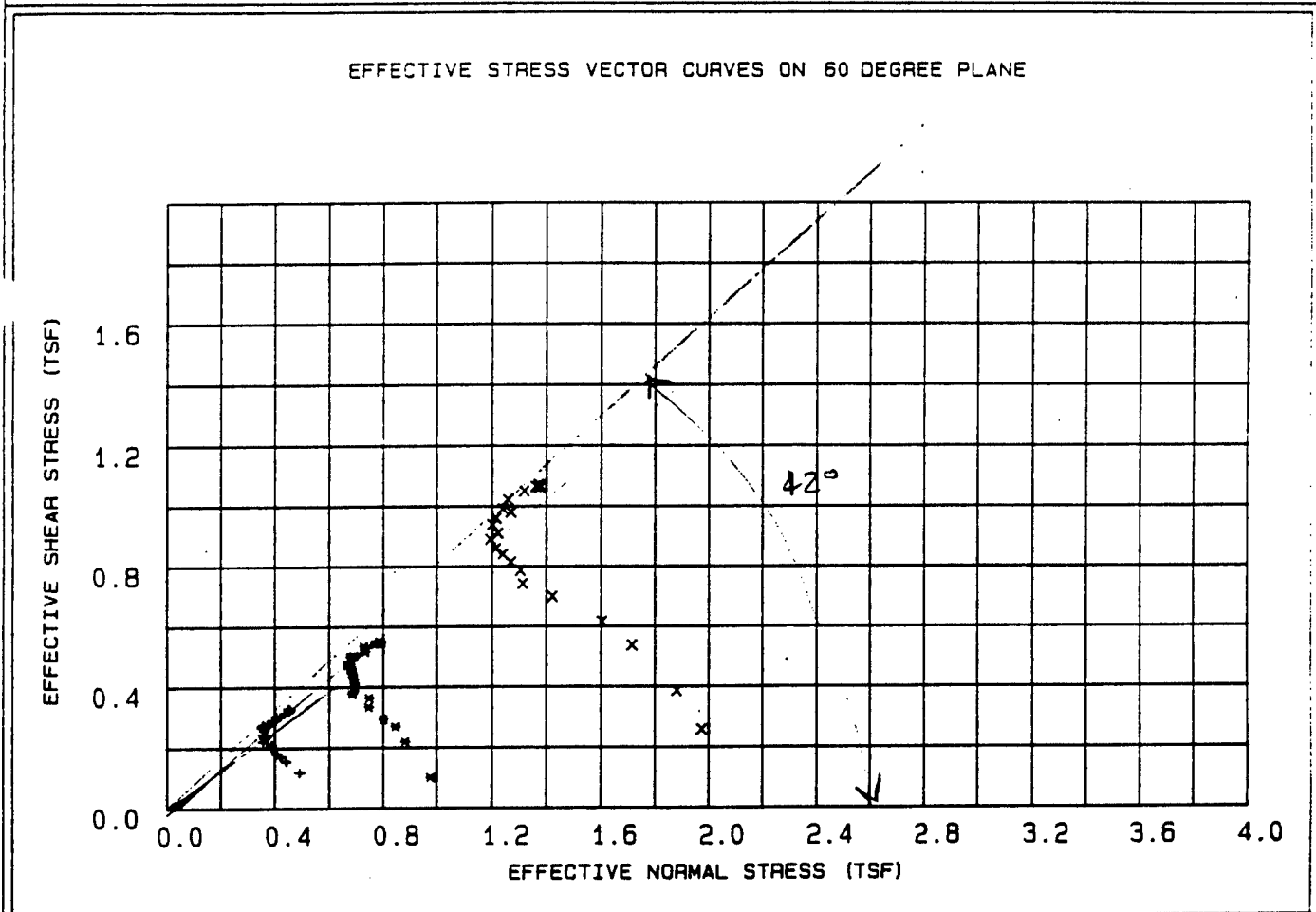
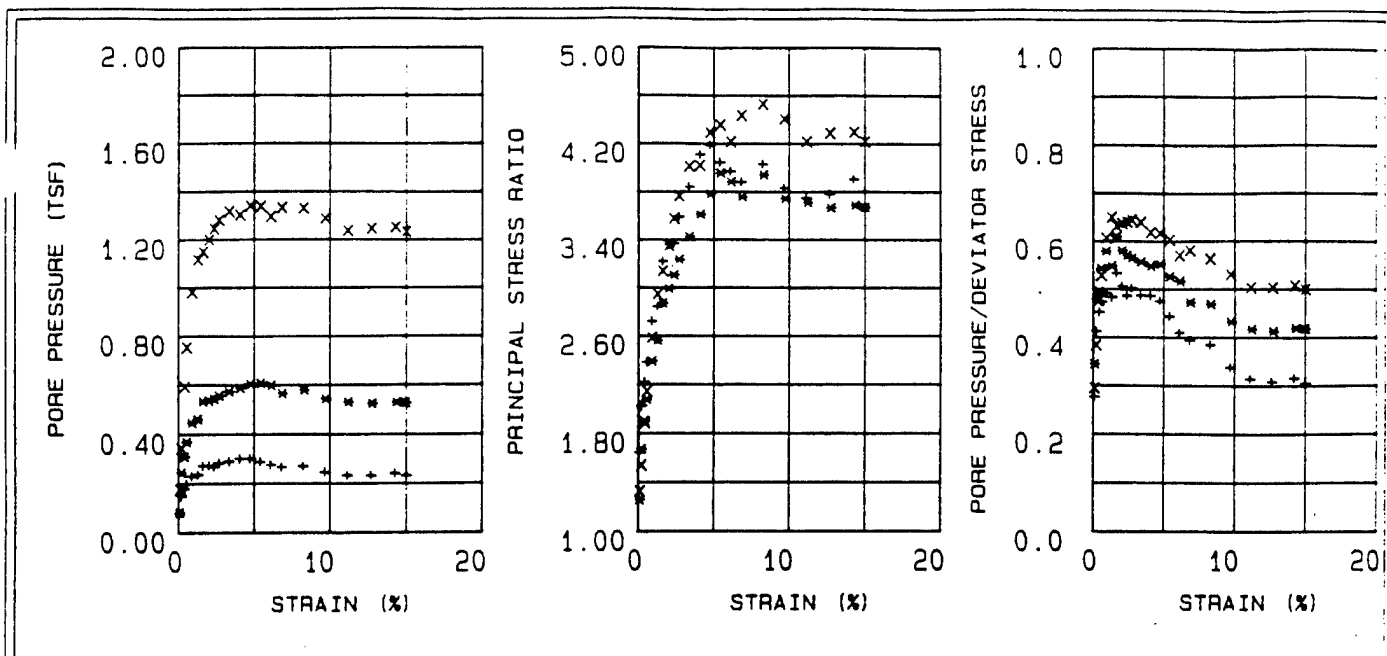
Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
54.0	257.1	67.8	1.450		99.1
34.5	257.1	72.7	1.283	0.10	71.5
34.5	257.1	73.4	1.260	0.25	72.8
34.5	257.1	74.6	1.226	0.50	74.9
34.5	257.1	77.7	1.135	1.00	80.9
34.5	257.1	82.2	1.019	2.00	90.1
34.5	257.1	87.1	0.906	4.00	100.0
34.5	257.1	93.2	0.781	8.00	100.0
34.5	257.1	92.0	0.804	2.00	100.0
34.5	257.1	90.1	0.843	0.50	100.0
34.5	257.1	88.6	0.872	0.10	100.0

Axial Strain (%)	Void Ratio
------------------	------------

1	1.425
2	1.401
3	1.376
4	1.352
5	1.327
6	1.303
7	1.278
8	1.254
9	1.229
10	1.205
11	1.180
12	1.156
13	1.131
14	1.107
15	1.082
16	1.058
17	1.033
18	1.009
19	0.984
20	0.960







<b>LEGEND</b> + = .5 TSF * = 1 TSF x = 2 TSF	
<b>PROJECT</b>	MINNESOTA RIVER; IA-90-04-ED-GH
<b>BORING NO.</b>	89-126MU
<b>SAMPLE NO.</b>	S-1
<b>DEPTH/ELEV</b>	12.0'-14.0'
<b>MRD LAB NO.</b>	90/135

FIGURE 23 Figure C-472

Table 7 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-126MU  
 Sample Number : S-1  
 Depth : 12.0'-14.0'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.273	0.075	1.642	0.276	0.492	0.118
30	0.22	0.360	0.148	2.024	0.412	0.441	0.155
45	0.44	0.393	0.177	2.218	0.452	0.420	0.170
60	0.58	0.418	0.198	2.382	0.474	0.405	0.180
90	0.92	0.466	0.229	2.719	0.491	0.386	0.201
120	1.29	0.487	0.235	2.841	0.483	0.386	0.210
150	1.63	0.509	0.271	3.220	0.533	0.355	0.220
180	2.02	0.538	0.272	3.359	0.506	0.361	0.232
210	2.36	0.551	0.268	3.368	0.486	0.368	0.238
240	2.70	0.563	0.283	3.589	0.502	0.356	0.243
300	3.36	0.596	0.290	3.840	0.487	0.358	0.257
360	4.06	0.619	0.301	4.109	0.486	0.352	0.267
420	4.72	0.634	0.301	4.185	0.475	0.356	0.274
	5.40	0.649	0.287	4.043	0.443	0.374	0.280
	6.09	0.671	0.274	3.969	0.409	0.392	0.290
600	6.81	0.676	0.265	3.879	0.393	0.402	0.292
720	8.22	0.701	0.269	4.029	0.384	0.405	0.303
840	9.66	0.725	0.244	3.829	0.337	0.435	0.313
960	11.10	0.739	0.231	3.746	0.313	0.452	0.319
1080	12.63	0.750	0.230	3.777	0.307	0.456	0.324
1200	14.21	0.759	0.239	3.904	0.315	0.449	0.328
1261	15.00	0.756	0.230	3.800	0.304	0.457	0.326

Table 8 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-126MU  
 Sample Number : S-1  
 Depth : 12.0'-14.0'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.234	0.081	1.255	0.344	0.977	0.101
30	0.22	0.508	0.243	1.671	0.479	0.883	0.219
45	0.44	0.623	0.308	1.900	0.495	0.846	0.269
60	0.59	0.679	0.368	2.075	0.543	0.800	0.293
90	0.93	0.771	0.446	2.391	0.579	0.745	0.333
120	1.30	0.842	0.461	2.563	0.548	0.747	0.363
150	1.65	0.874	0.533	2.871	0.610	0.684	0.377
180	2.04	0.925	0.536	2.992	0.580	0.693	0.399
210	2.39	0.957	0.545	3.103	0.570	0.692	0.413
240	2.73	0.988	0.557	3.233	0.564	0.688	0.427
300	3.39	1.032	0.574	3.425	0.557	0.682	0.445
360	4.11	1.074	0.588	3.609	0.548	0.678	0.464
420	4.77	1.097	0.605	3.781	0.552	0.667	0.474
480	5.46	1.157	0.608	3.955	0.526	0.678	0.499
540	6.15	1.160	0.598	3.883	0.516	0.689	0.501
600	6.88	1.199	0.565	3.756	0.472	0.732	0.517
720	8.31	1.238	0.579	3.941	0.468	0.728	0.534
840	9.76	1.257	0.542	3.743	0.432	0.769	0.542
960	11.21	1.274	0.529	3.708	0.416	0.787	0.550
1080	12.76	1.270	0.523	3.665	0.412	0.792	0.548
1200	14.36	1.264	0.529	3.687	0.419	0.784	0.546
1249	15.00	1.262	0.527	3.667	0.418	0.786	0.545

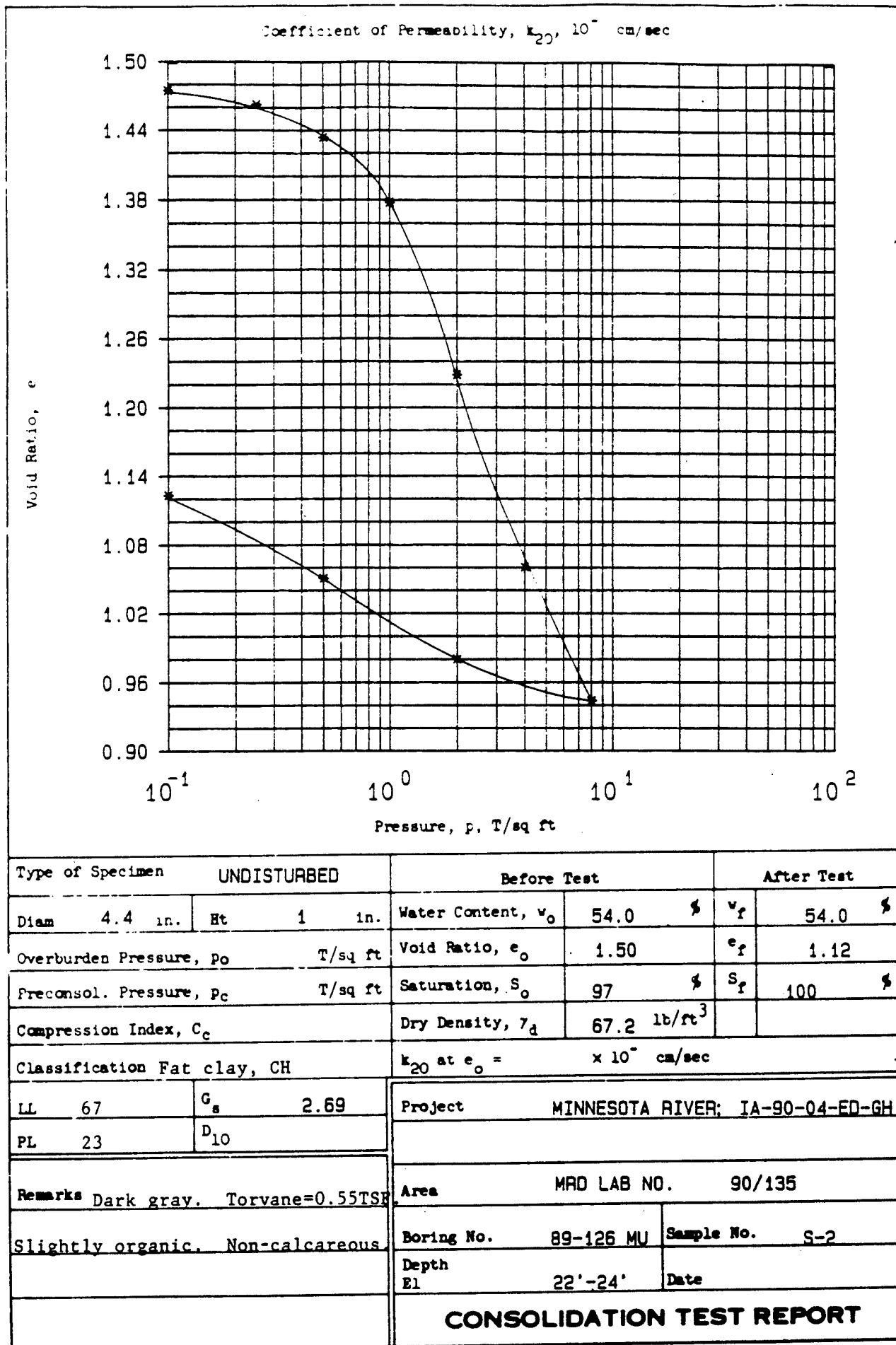
Table 9 - Triaxial  $\bar{R}$  Test Results

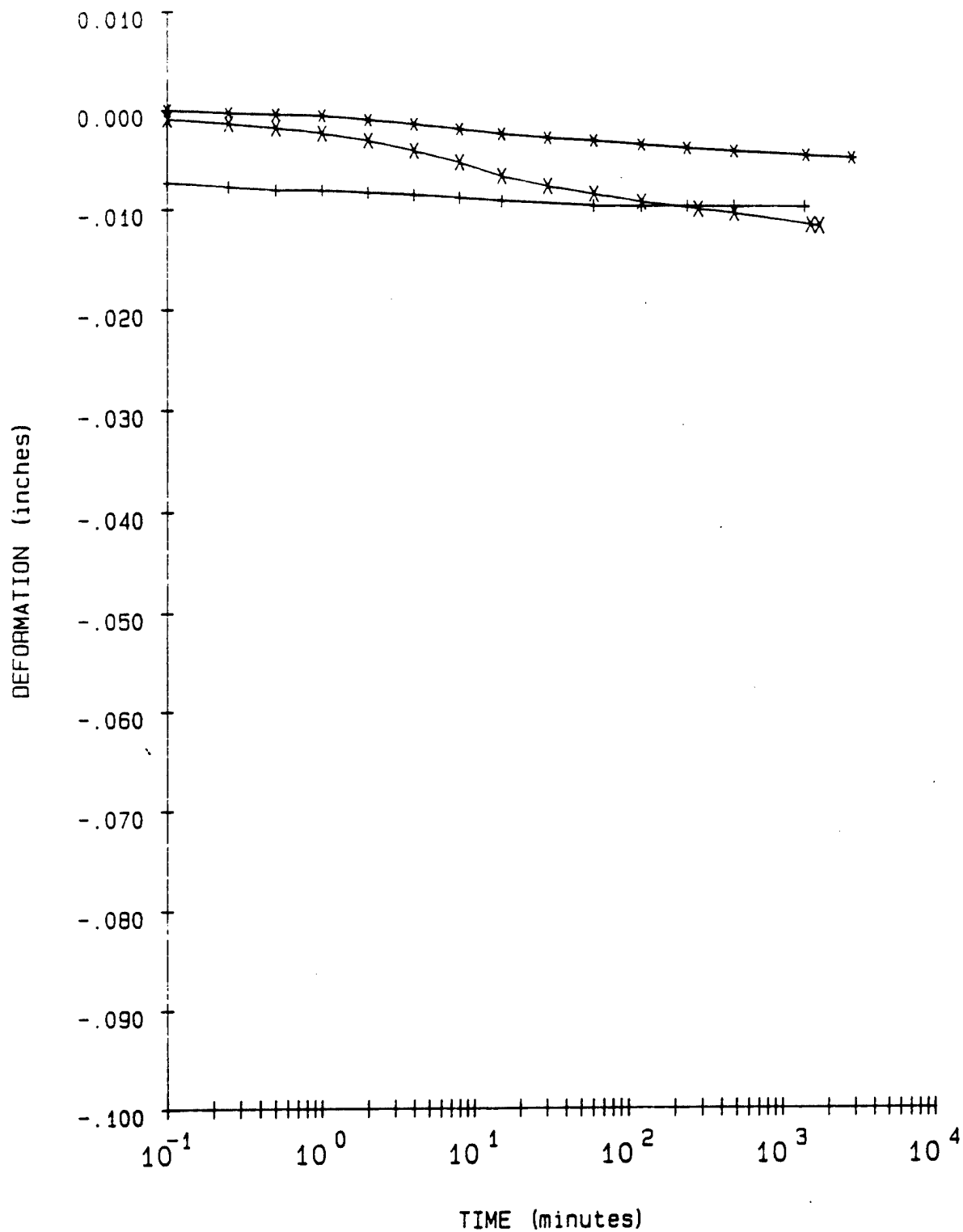
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-126MU  
 Sample Number : S-1  
 Depth : 12.0'-14.0'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.595	0.174	1.326	0.294	1.973	0.257
30	0.22	0.892	0.341	1.538	0.383	1.880	0.385
45	0.44	1.241	0.592	1.882	0.477	1.715	0.536
60	0.59	1.424	0.752	2.141	0.528	1.601	0.615
90	0.93	1.619	0.980	2.587	0.606	1.421	0.699
120	1.30	1.720	1.115	2.944	0.649	1.311	0.742
150	1.64	1.821	1.148	3.137	0.631	1.303	0.786
180	2.03	1.883	1.198	3.349	0.637	1.268	0.813
210	2.37	1.946	1.244	3.574	0.640	1.238	0.840
240	2.71	1.990	1.280	3.763	0.644	1.213	0.859
300	3.37	2.060	1.316	4.011	0.639	1.194	0.889
360	4.08	2.109	1.301	4.018	0.618	1.221	0.910
420	4.74	2.176	1.339	4.291	0.616	1.200	0.939
480	5.43	2.224	1.337	4.355	0.602	1.214	0.960
540	6.11	2.271	1.293	4.212	0.570	1.269	0.980
600	6.84	2.297	1.331	4.432	0.580	1.238	0.992
720	8.26	2.367	1.329	4.528	0.562	1.257	1.022
840	9.71	2.433	1.285	4.402	0.529	1.317	1.050
960	11.15	2.461	1.234	4.214	0.502	1.375	1.062
1080	12.69	2.483	1.244	4.285	0.502	1.371	1.072
1200	14.27	2.468	1.251	4.294	0.507	1.360	1.065
1256	15.00	2.469	1.231	4.215	0.499	1.379	1.066









LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-126 MU

SAMPLE NO.

S-2

DEPTH/ELEV

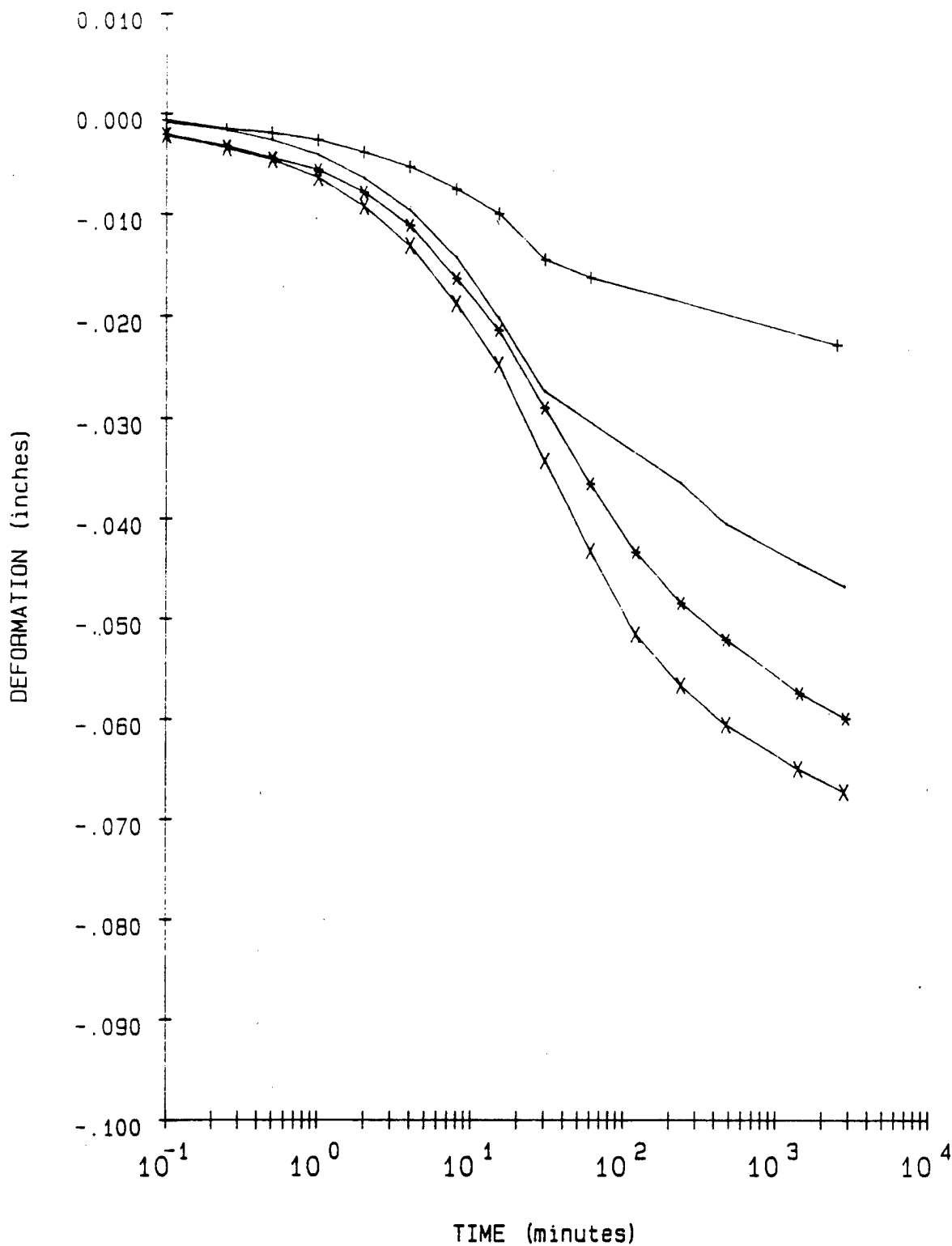
22'-24'

MRD LAB NO.

90/135

FIGURE 6

Figure C-478



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-126 MU

SAMPLE NO.

S-2

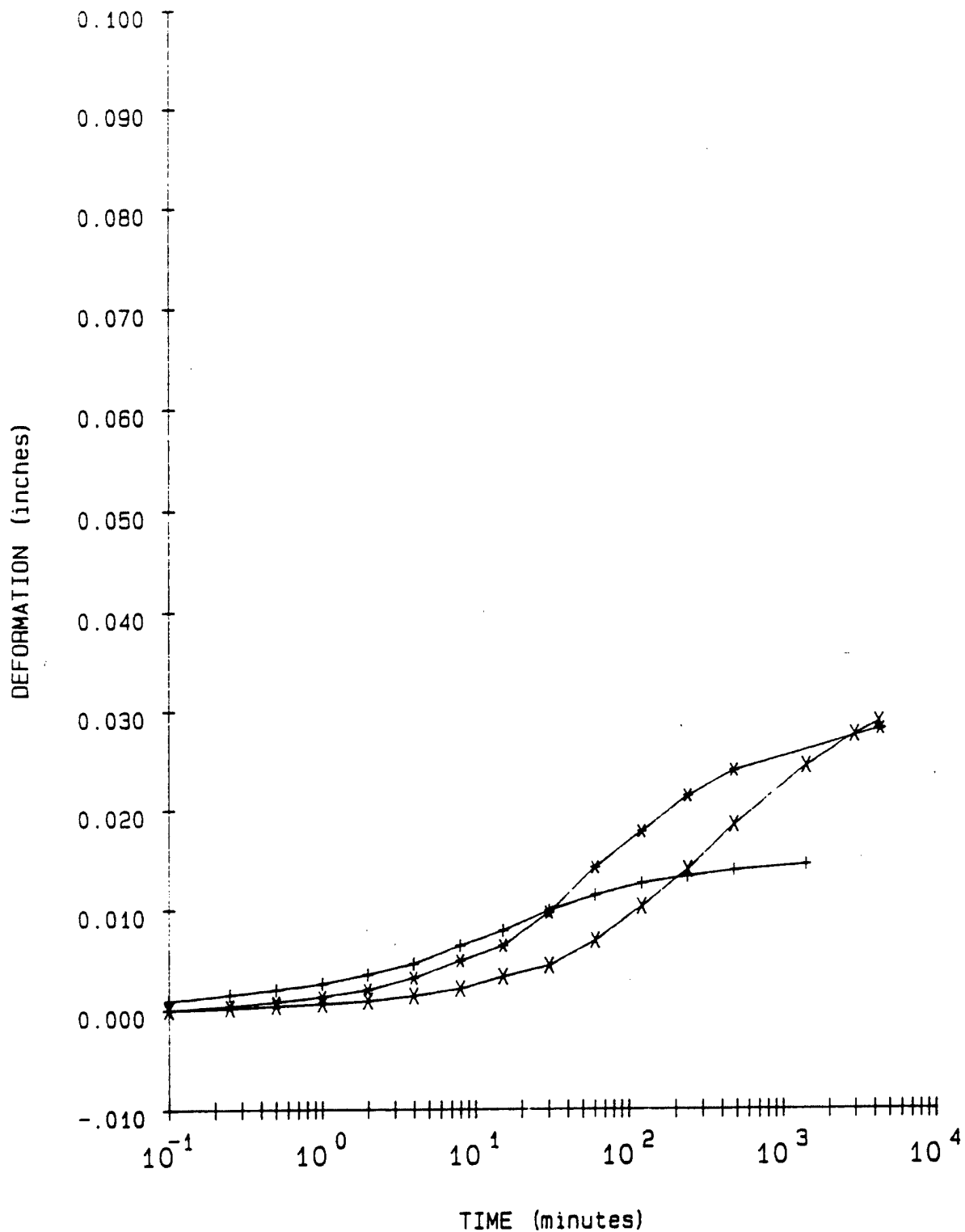
DEPTH/ELEV

22'-24'

MRD LAB NO.

90/135

FIGURE 7



LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

PROJECT MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO. 89-126 MU

SAMPLE NO. S-2

DEPTH/ELEV 22'-24'

MRD LAB NO. 90/135

FIGURE 8

Figure C-480

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-126 MU

Sample No. S-2

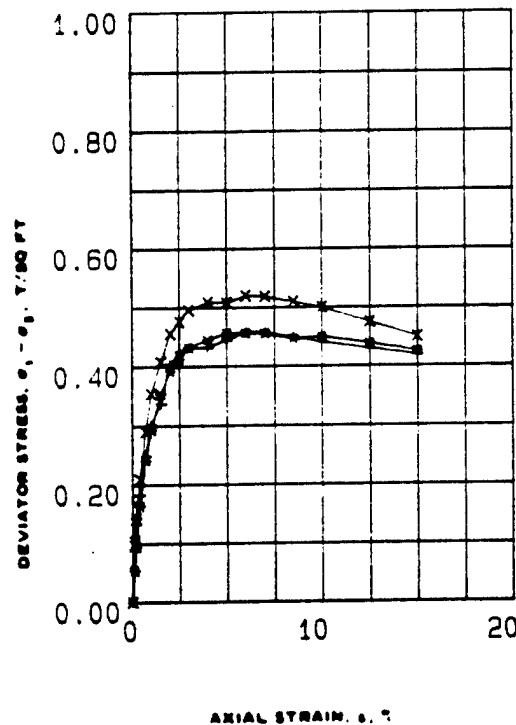
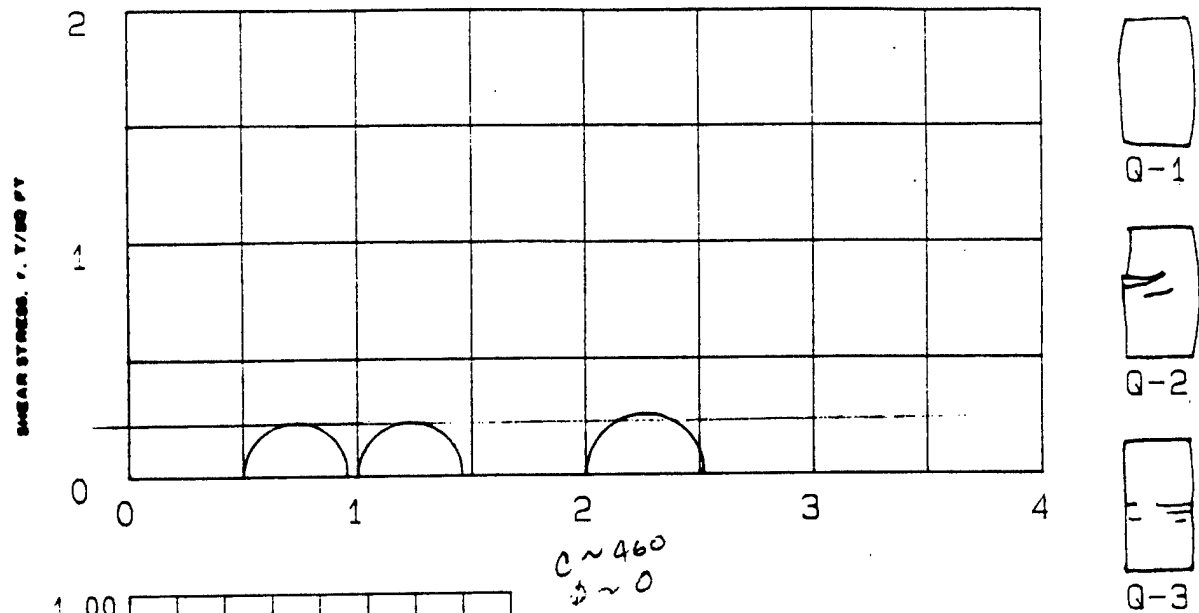
Depth/Elev 22'-24'

MRD Lab No. 90/135

Gs = 2.69  
eo = 1.499  
0.42eo = 0.629

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
54.0	272.9	67.2	1.499		96.9
54.0	272.9	67.8	1.474	0.10	98.5
54.0	272.9	68.2	1.463	0.25	99.3
54.0	272.9	69.0	1.434	0.50	100.0
54.0	272.9	70.6	1.377	1.00	100.0
54.0	272.9	75.3	1.228	2.00	100.0
54.0	272.9	81.5	1.060	4.00	100.0
54.0	272.9	86.4	0.944	8.00	100.0
54.0	272.9	84.8	0.980	2.00	100.0
54.0	272.9	81.9	1.051	0.50	100.0
54.0	272.9	79.1	1.123	0.10	100.0

Axial Strain (%)	Void Ratio
1	1.474
2	1.449
3	1.424
4	1.399
5	1.374
6	1.349
7	1.324
8	1.299
9	1.274
10	1.249
11	1.224
12	1.199
13	1.174
14	1.149
15	1.124
16	1.099
17	1.074
18	1.049
19	1.024
20	0.999



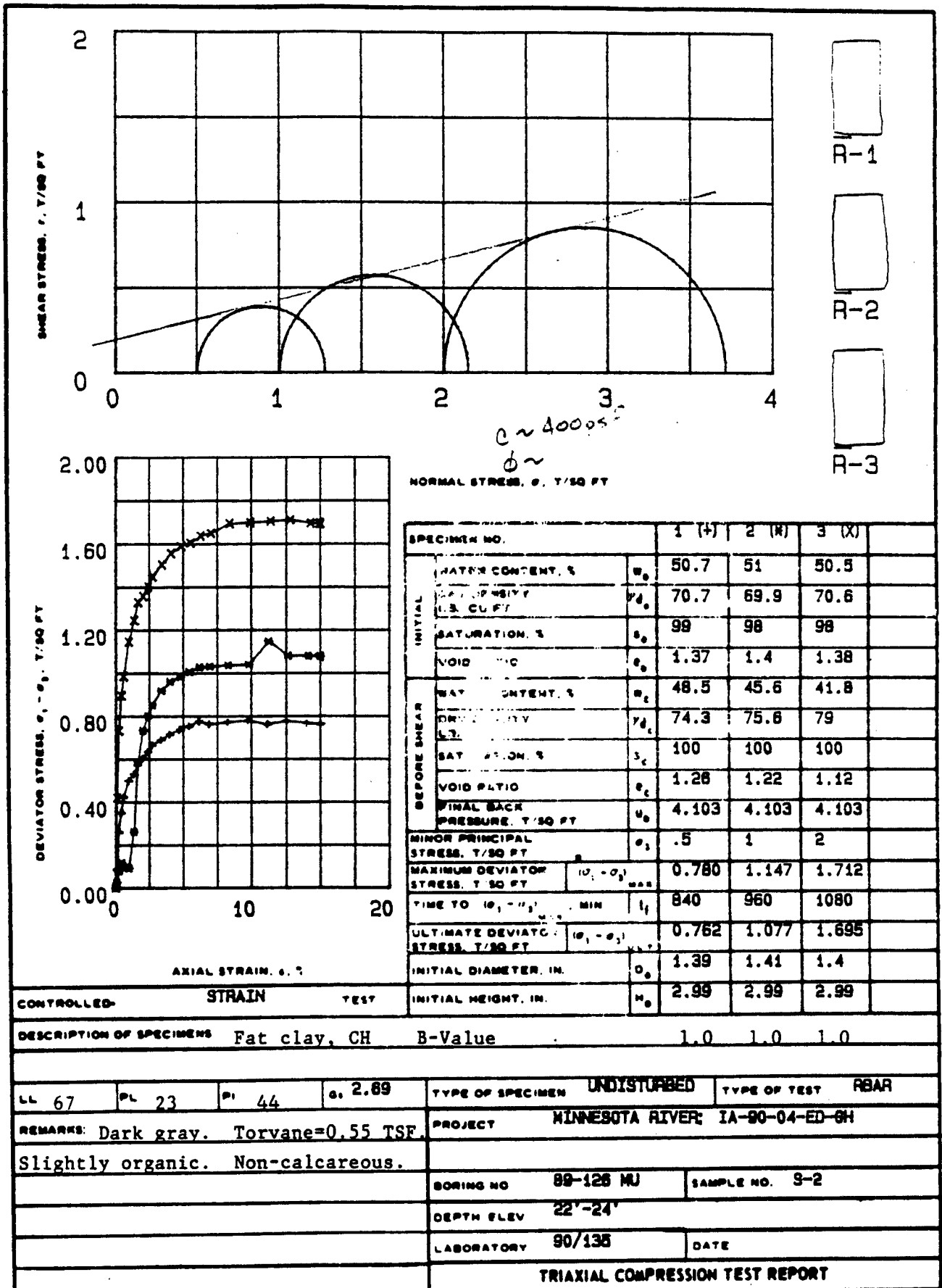
NORMAL STRESS,  $\sigma$ , T/50 FT

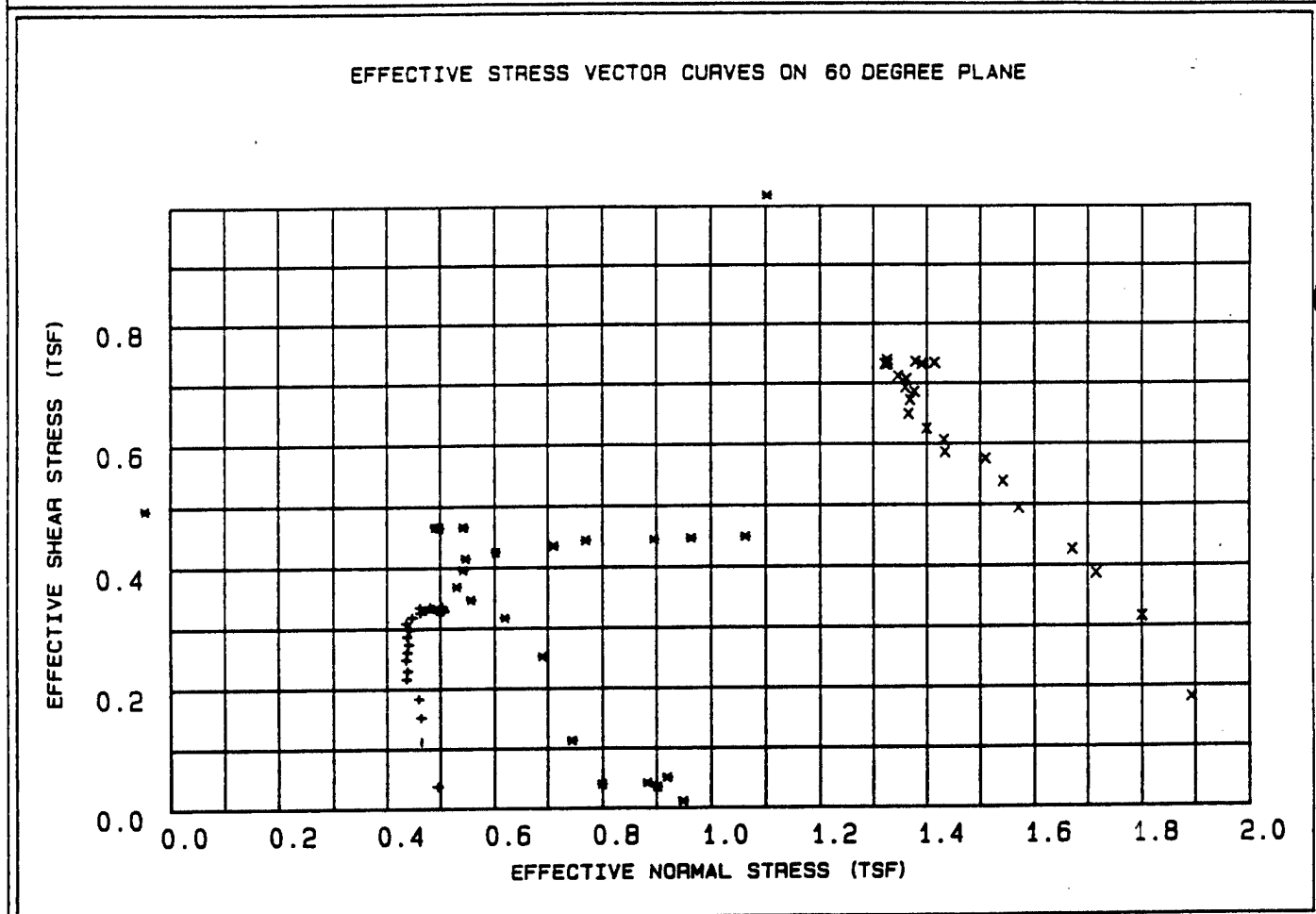
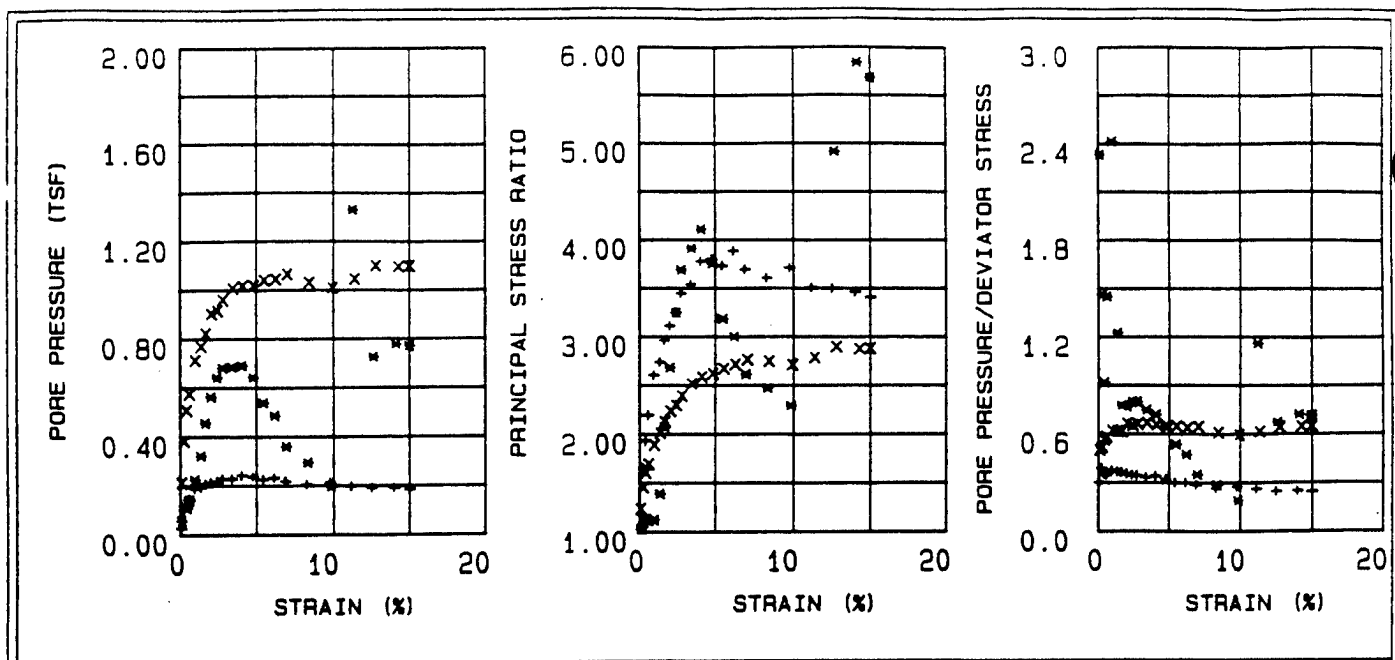
SPECIMEN NO.		1 (+)	2 (*)	3 (X)
INITIAL	WATER CONTENT, %	49.4	49.7	50.0
	DRY DENSITY LB/ CU FT	73.5	71.3	72.3
	SATURATION, %	100.0	98.0	100.0
	VOID RATIO	1.28	1.36	1.32
BEFORE SHEAR	WATER CONTENT, %	49.3	49.4	49.9
	DRY DENSITY LB/ CU FT	73.5	71.3	72.3
	SATURATION, %	100.0	98.0	100.0
	VOID RATIO	1.28	1.36	1.32
FINAL BACK PRESSURE, T/50 FT		0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		0.5	1.0	2.0
MAXIMUM DEVIATOR STRESS, T/50 FT		0.46	0.46	0.52
TIME TO $\sigma_1 = \sigma_3$ , MIN		13.0	10.5	12.5
ULTIMATE DEVIATOR STRESS, T/50 FT		0.42	0.43	0.45
INITIAL DIAMETER, IN.		1.40	1.42	1.40
INITIAL HEIGHT, IN.		2.97	2.98	2.98

CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS Fat clay, CH

LL 67	PL 23	PI 44	G <sub>s</sub> 2.69	TYPE OF SPECIMEN	UNDISTURBED	TYPE OF TEST	Q	
REMARKS: Dark gray. Torvane=0.55 TSF.				PROJECT				MINNESOTA RIVER; IA-90-04-ED-6H
Slightly organic. Non-calcareous.				BORING NO				89-126 MU
				SAMPLE NO.				S-2
				DEPTH ELEV				22'-24'
				LABORATORY				90/135
				DATE				
TRIAXIAL COMPRESSION TEST REPORT								





<p><b>LEGEND</b></p> <p>+ = .5 TSF</p> <p>* = 1 TSF</p> <p>x = 2 TSF</p>	<p><b>PROJECT</b> MINNESOTA RIVER: IA-90-04-ED-GII</p> <p><b>BORING NO.</b> 89-126 MU</p> <p><b>SAMPLE NO.</b> S-2</p> <p><b>DEPTH/ELEV</b> 22'-24'</p> <p><b>MRD LAB NO.</b> 90/135</p>
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FIGURE 11  
Figure C-484



Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-126 MU  
 Sample Number : S-2  
 Depth : 22'-24'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.086	0.026	1.181	0.301	0.495	0.037
30	0.26	0.261	0.101	1.653	0.388	0.464	0.112
45	0.43	0.351	0.124	1.933	0.353	0.463	0.152
60	0.60	0.423	0.146	2.196	0.346	0.459	0.183
90	0.96	0.501	0.188	2.604	0.375	0.436	0.216
120	1.35	0.532	0.194	2.738	0.365	0.438	0.230
150	1.64	0.574	0.207	2.960	0.362	0.435	0.248
180	2.00	0.605	0.213	3.110	0.353	0.437	0.261
210	2.39	0.635	0.217	3.248	0.343	0.440	0.274
240	2.73	0.666	0.228	3.447	0.342	0.437	0.287
300	3.37	0.691	0.228	3.540	0.330	0.443	0.298
360	4.03	0.716	0.242	3.778	0.339	0.435	0.309
420	4.75	0.739	0.236	3.801	0.320	0.447	0.319
480	5.42	0.754	0.224	3.729	0.297	0.463	0.326
540	6.15	0.776	0.231	3.885	0.298	0.461	0.335
600	6.89	0.763	0.216	3.691	0.284	0.473	0.329
720	8.27	0.773	0.203	3.602	0.263	0.488	0.333
840	9.74	0.780	0.212	3.710	0.273	0.481	0.336
960	11.14	0.762	0.196	3.505	0.258	0.493	0.329
1080	12.51	0.777	0.189	3.496	0.243	0.503	0.336
1200	13.98	0.766	0.189	3.459	0.247	0.501	0.330
1280	15.00	0.762	0.183	3.406	0.241	0.506	0.329
1280	15.00	0.762	0.183	3.406	0.241	0.506	0.329

Table 5 - Triaxial  $\bar{R}$  Test Results

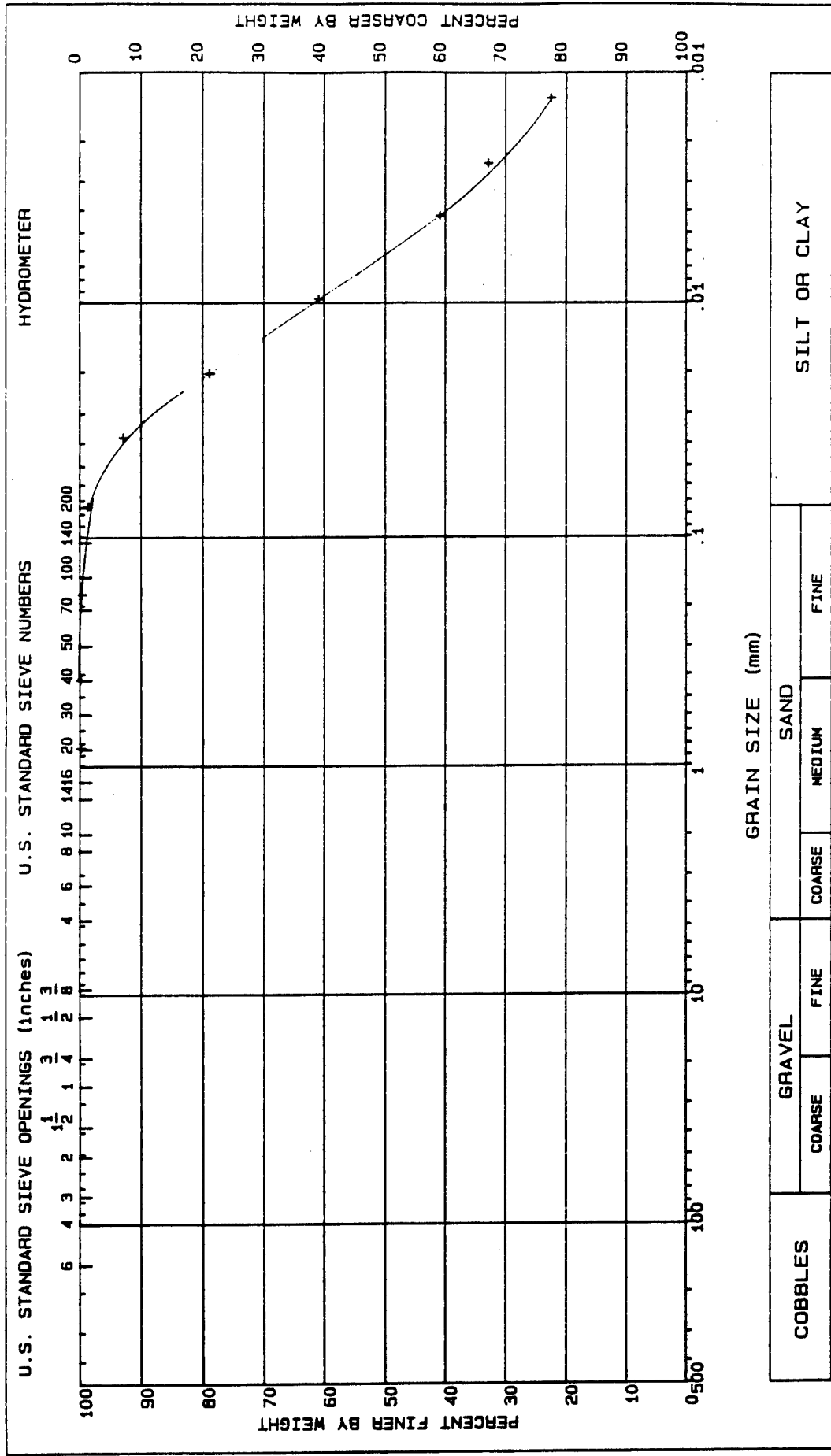
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-126 MU  
 Sample Number : S-2  
 Depth : 22'-24'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.025	0.057	1.026	2.330	0.949	0.011
30	0.27	0.081	0.119	1.092	1.458	0.901	0.035
45	0.44	0.119	0.109	1.133	0.915	0.920	0.051
60	0.61	0.097	0.141	1.113	1.449	0.883	0.042
90	0.97	0.093	0.224	1.120	2.412	0.799	0.040
120	1.36	0.263	0.321	1.387	1.223	0.744	0.113
150	1.66	0.587	0.455	2.076	0.775	0.690	0.253
180	2.02	0.735	0.563	2.682	0.767	0.619	0.317
210	2.41	0.804	0.642	3.248	0.799	0.557	0.347
240	2.75	0.855	0.682	3.688	0.798	0.530	0.369
300	3.41	0.919	0.685	3.914	0.746	0.542	0.396
360	4.07	0.962	0.691	4.109	0.718	0.547	0.415
420	4.80	0.984	0.642	3.751	0.653	0.602	0.425
480	5.48	1.007	0.538	3.181	0.535	0.711	0.435
540	6.21	1.029	0.485	2.998	0.472	0.770	0.444
600	6.97	1.031	0.359	2.608	0.349	0.896	0.445
720	8.35	1.037	0.293	2.467	0.283	0.964	0.447
840	9.84	1.039	0.194	2.289	0.187	1.063	0.449
960	11.25	1.147	1.330	-2.477	1.160	-0.046	0.495
1080	12.64	1.080	0.724	4.918	0.671	0.543	0.466
1200	14.13	1.079	0.777	5.842	0.721	0.490	0.466
1268	15.00	1.077	0.770	5.680	0.715	0.497	0.465
1268	15.00	1.077	0.770	5.680	0.715	0.497	0.465

Table 6 - Triaxial  $\bar{R}$  Test Results

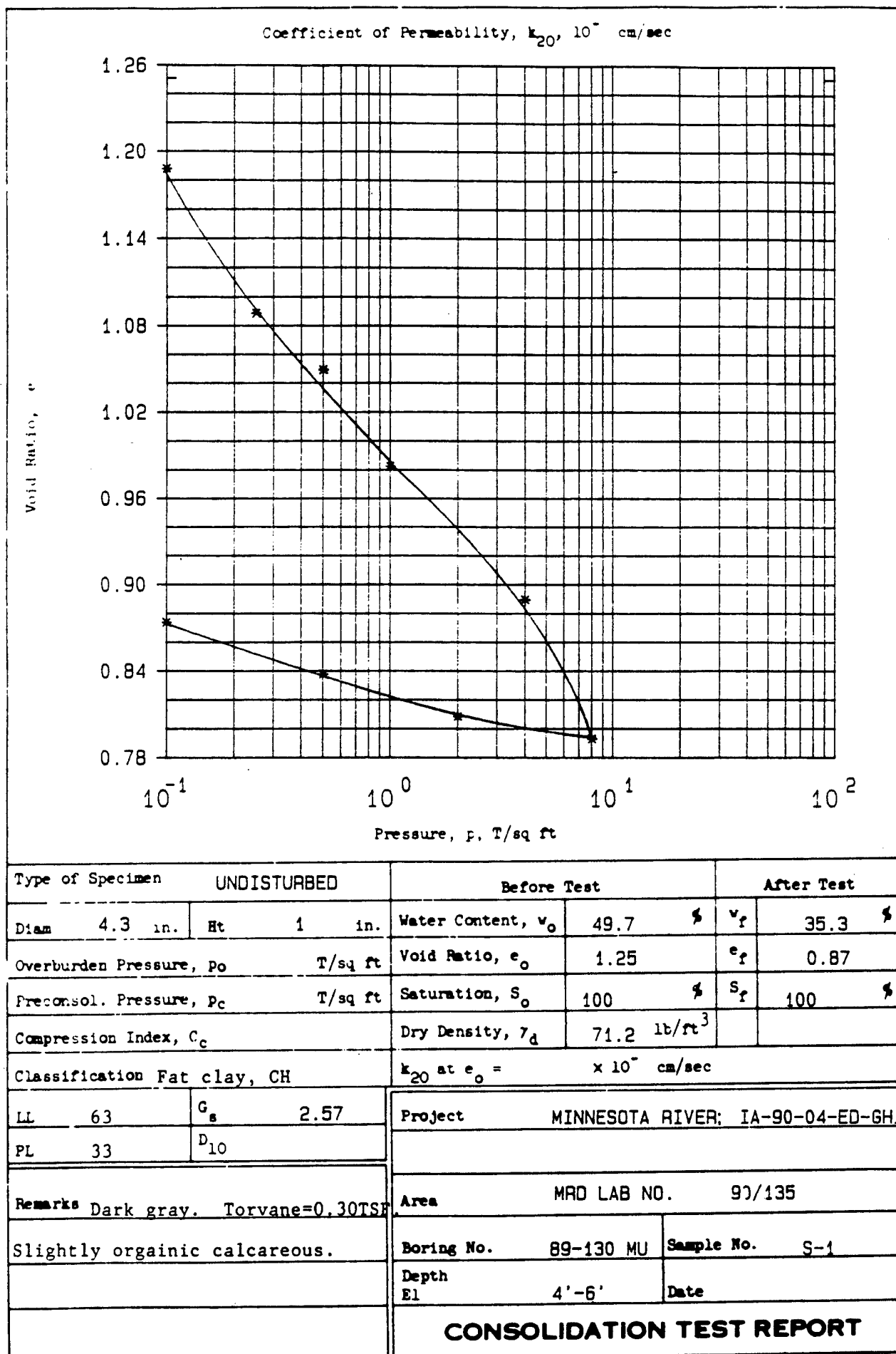
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-126 MU  
 Sample Number : S-2  
 Depth : 22'-24'  
 Confining Pressure : 2 TSF

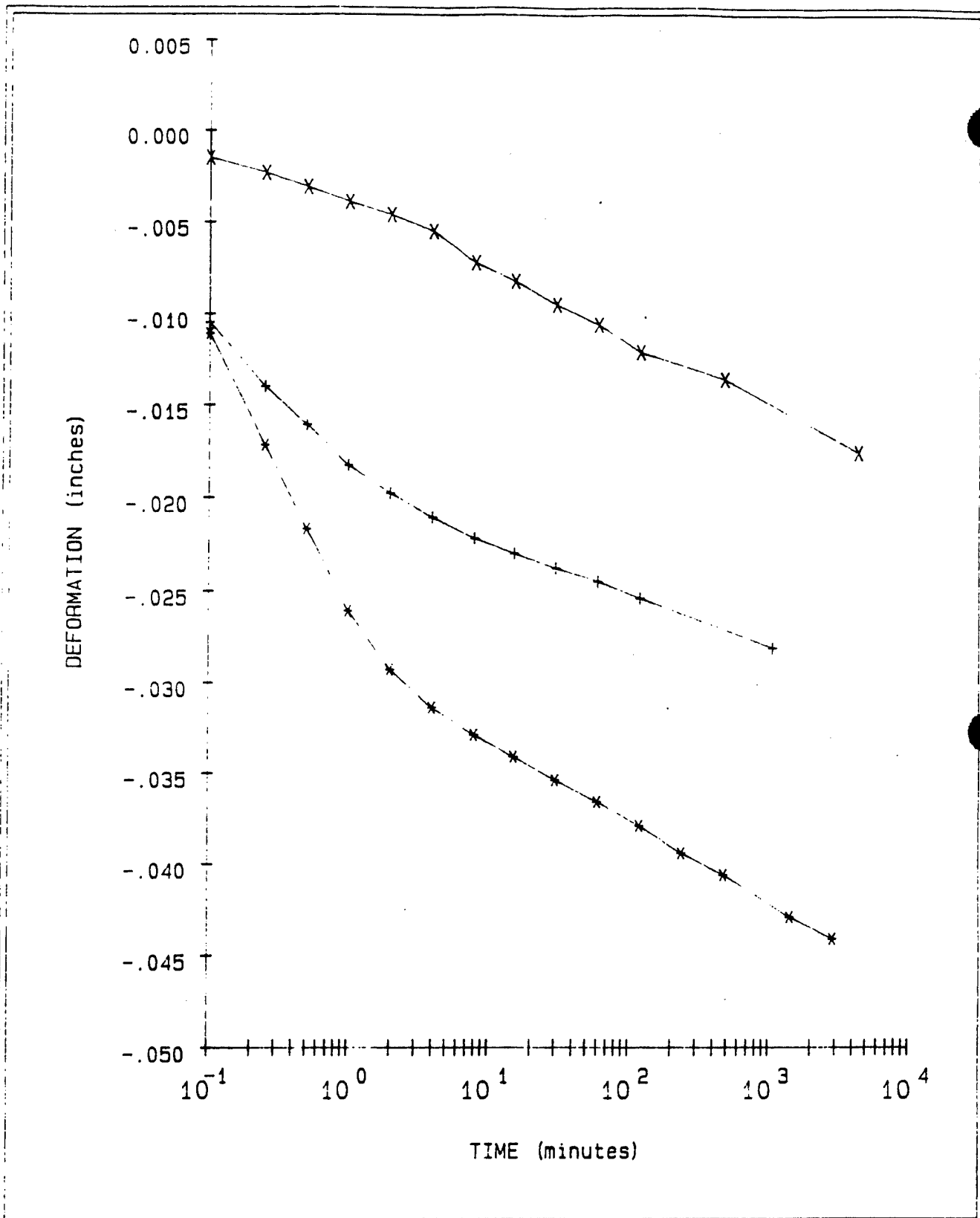
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.420	0.211	1.234	0.502	1.893	0.181
30	0.27	0.733	0.382	1.453	0.521	1.800	0.316
45	0.44	0.897	0.507	1.601	0.565	1.715	0.387
60	0.62	0.986	0.574	1.692	0.582	1.670	0.426
90	0.99	1.145	0.712	1.889	0.622	1.571	0.494
120	1.38	1.246	0.768	2.012	0.617	1.541	0.538
150	1.68	1.331	0.821	2.129	0.617	1.509	0.575
180	2.04	1.359	0.903	2.238	0.665	1.433	0.586
210	2.44	1.403	0.916	2.295	0.653	1.431	0.606
240	2.79	1.449	0.960	2.394	0.663	1.399	0.625
300	3.45	1.504	1.007	2.514	0.670	1.365	0.649
360	4.12	1.557	1.018	2.586	0.654	1.368	0.672
420	4.85	1.590	1.018	2.620	0.641	1.376	0.686
480	5.54	1.606	1.039	2.672	0.648	1.359	0.693
540	6.28	1.638	1.044	2.714	0.638	1.361	0.707
600	7.05	1.650	1.064	2.763	0.645	1.345	0.712
720	8.45	1.695	1.030	2.746	0.608	1.390	0.732
840	9.95	1.700	1.007	2.711	0.593	1.414	0.734
960	11.38	1.706	1.044	2.785	0.613	1.378	0.736
1080	12.79	1.712	1.099	2.899	0.642	1.325	0.739
1200	14.29	1.696	1.095	2.875	0.646	1.325	0.732
1254	15.00	1.695	1.098	2.880	0.648	1.321	0.732
1254	15.00	1.695	1.098	2.880	0.648	1.321	0.732



LL = 67	PL = 23	PI = 44	GS = 2.69	NAT W =	%	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH
CLASSIFICATION Fat clay, CH						BORING NO	89-126 MU
GRADATION CURVE						SAMPLE NO.	S-2
						DEPTH/ELEV	22'-24'
						MWD LAB NO.	90/135

Figure C-488

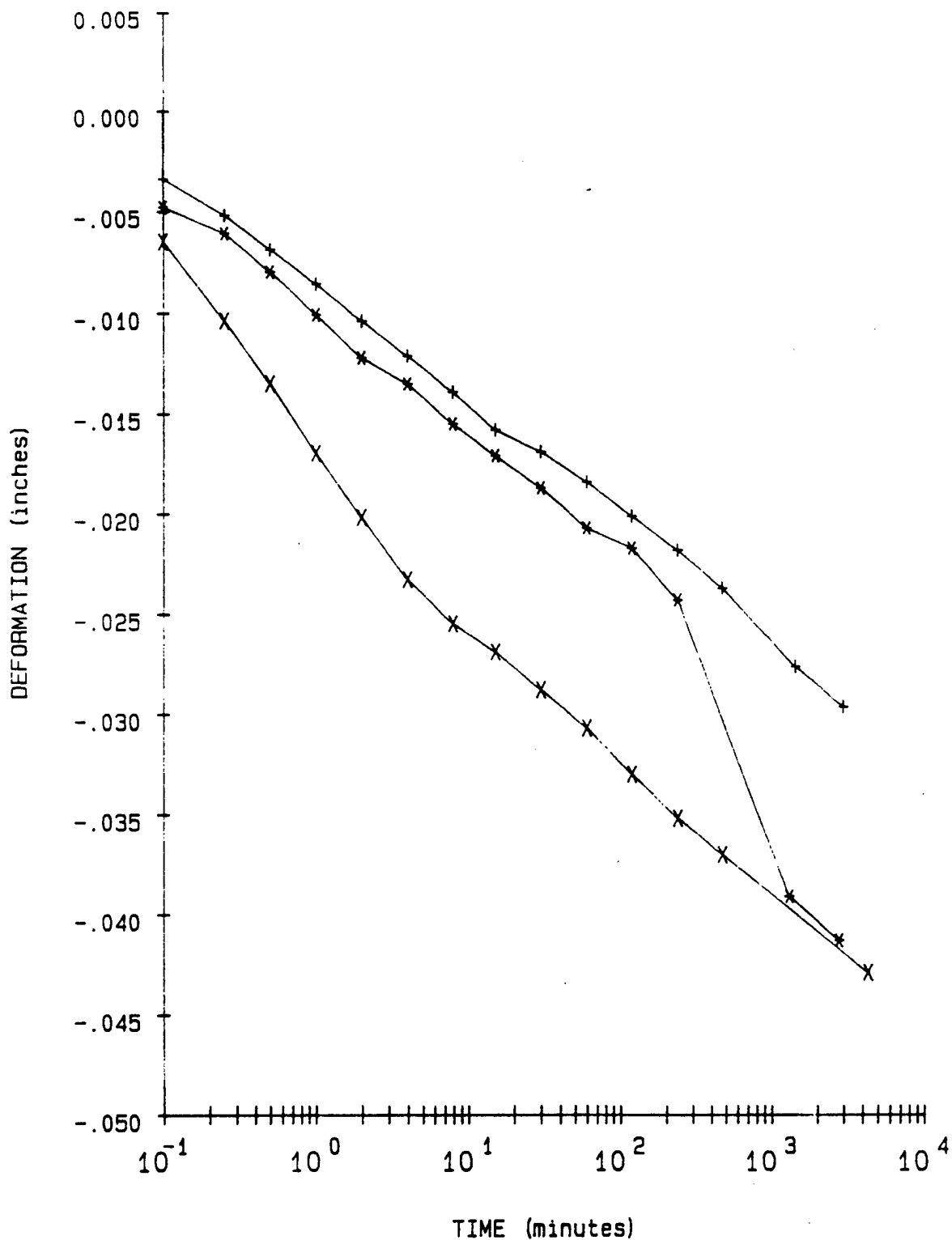




LEGEND  
 + = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT MINNESOTA RIVER; IA-90-04-ED-GH  
 BORING NO. 89-130 MU  
 SAMPLE NO. S-1  
 DEPTH/ELEV 4'-6'  
 MRD LAB NO. 90/135

FIGURE 2



LEGEND

+ = 2 TSF  
 \* = 4 TSF  
 X = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-1

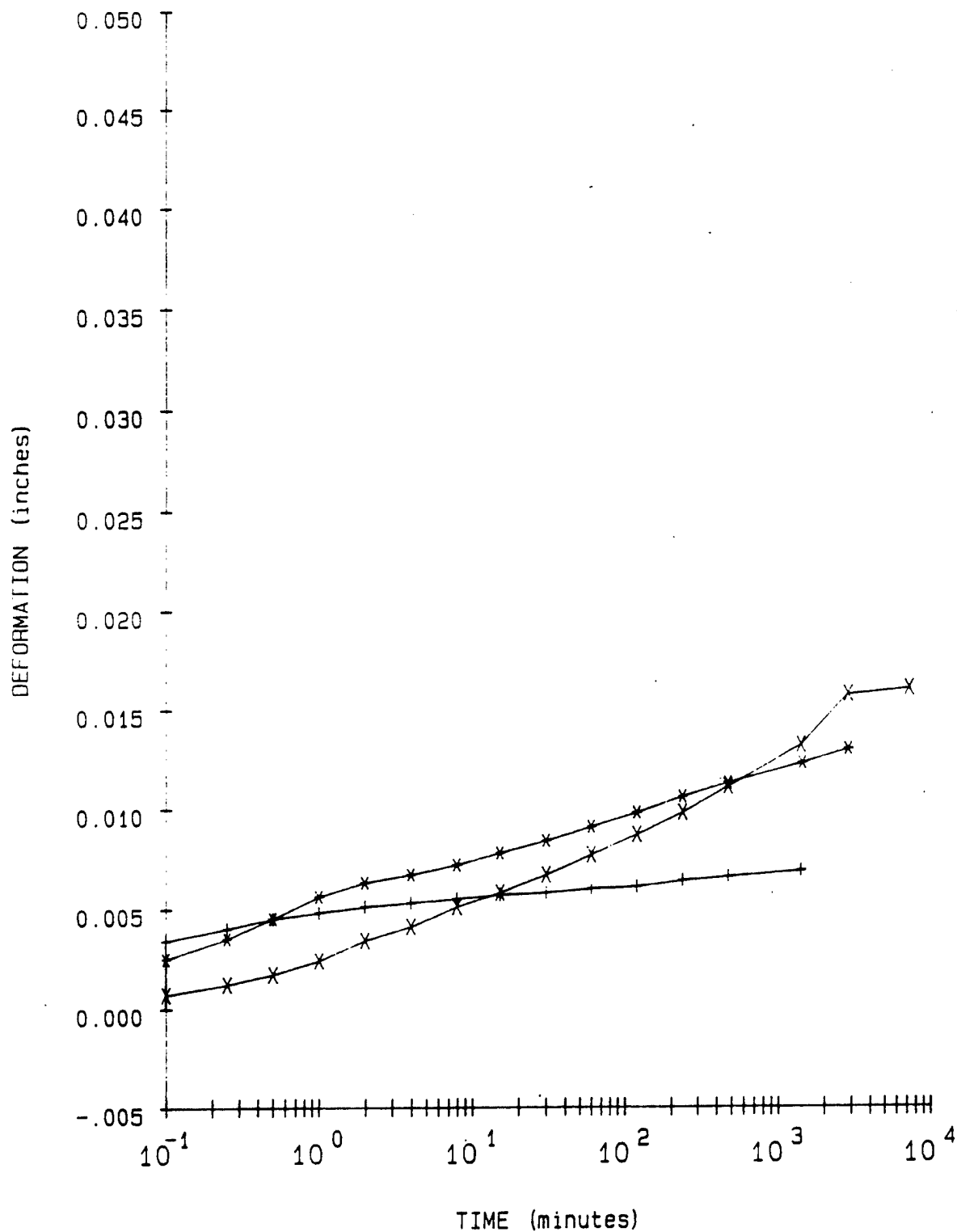
DEPTH/ELEV

4'-6'

MRO LAB NO.

90/135

FIGURE 3



#### LEGEND

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-1

DEPTH/ELEV

4'-6'

MRO LAB NO.

90/135

FIGURE 4



# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-130 MU

Sample No. S-1

Depth/Elev 4'-6'

MRD Lab No. 90/135

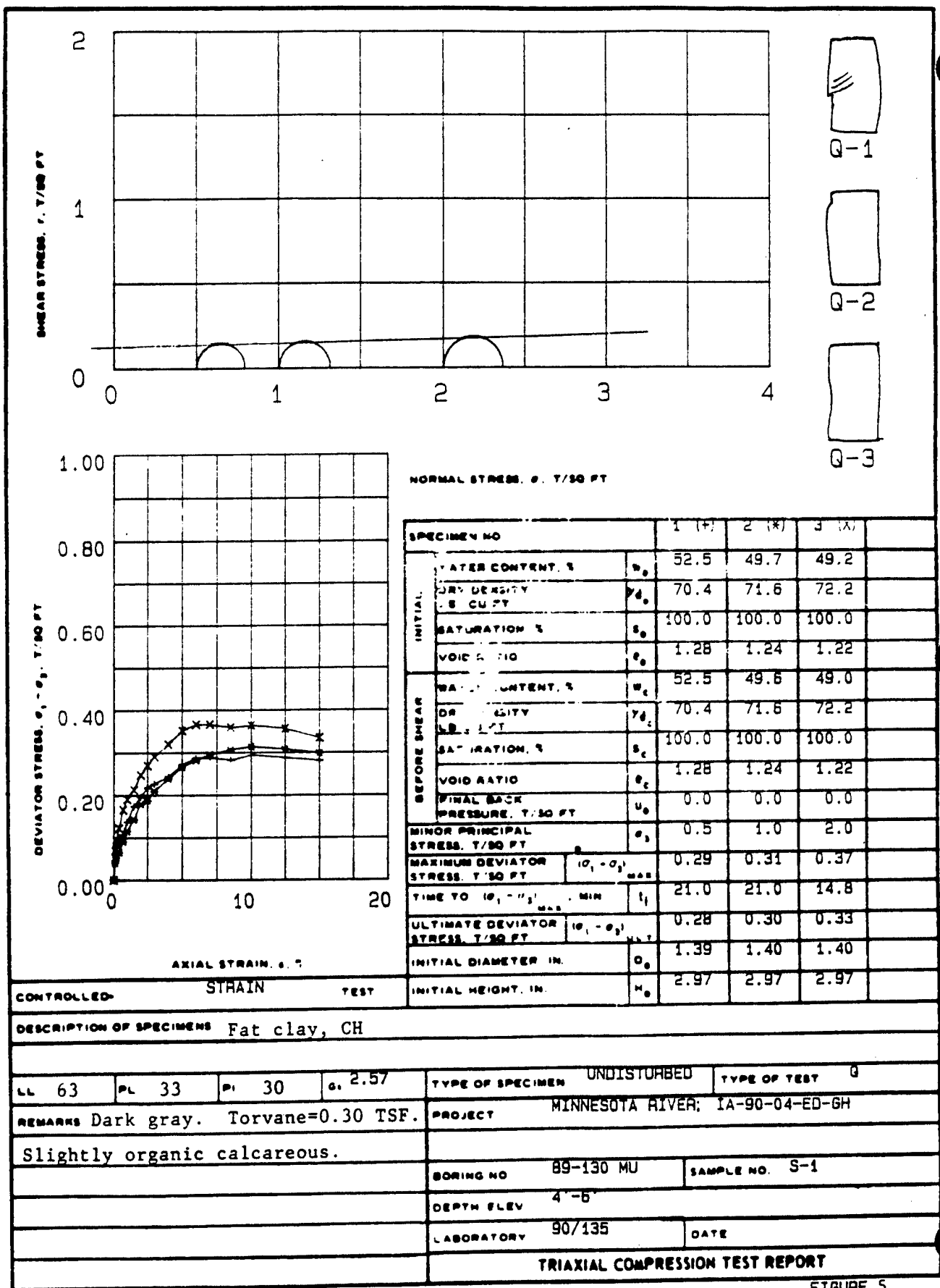
Gs = 2.57

eo = 1.251

0.42eo = 0.525

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
49.7	269.6	71.2	1.251		100.0
35.3	269.6	73.3	1.188	0.10	76.5
35.3	269.6	76.8	1.088	0.25	83.5
35.3	269.6	78.3	1.049	0.50	86.6
35.3	269.6	80.9	0.982	2.00	92.5
35.3	269.6	84.9	0.889	4.00	100.0
35.3	269.6	89.5	0.793	8.00	100.0
35.3	269.6	88.7	0.808	2.00	100.0
5.3	269.6	87.3	0.837	0.50	100.0
5.3	269.6	85.6	0.874	0.10	100.0

Axial Strain (%)	Void Ratio
1	1.228
2	1.206
3	1.183
4	1.161
5	1.138
6	1.116
7	1.093
8	1.071
9	1.048
10	1.026
11	1.003
12	0.981
13	0.958
14	0.936
15	0.913
16	0.891
17	0.868
18	0.846
19	0.823
20	0.801



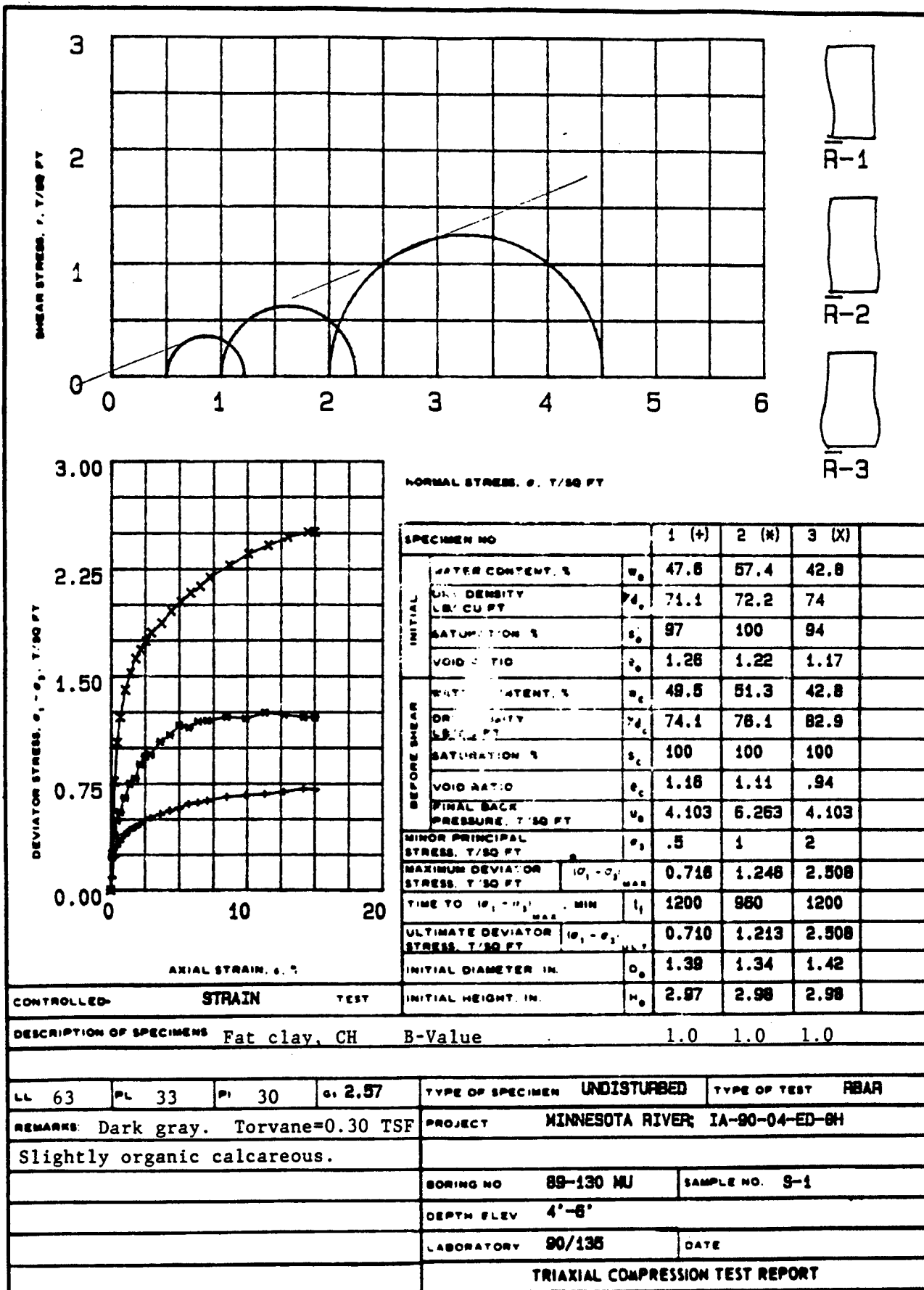
ENG FORM NO. 2088  
REV JUNE 1979

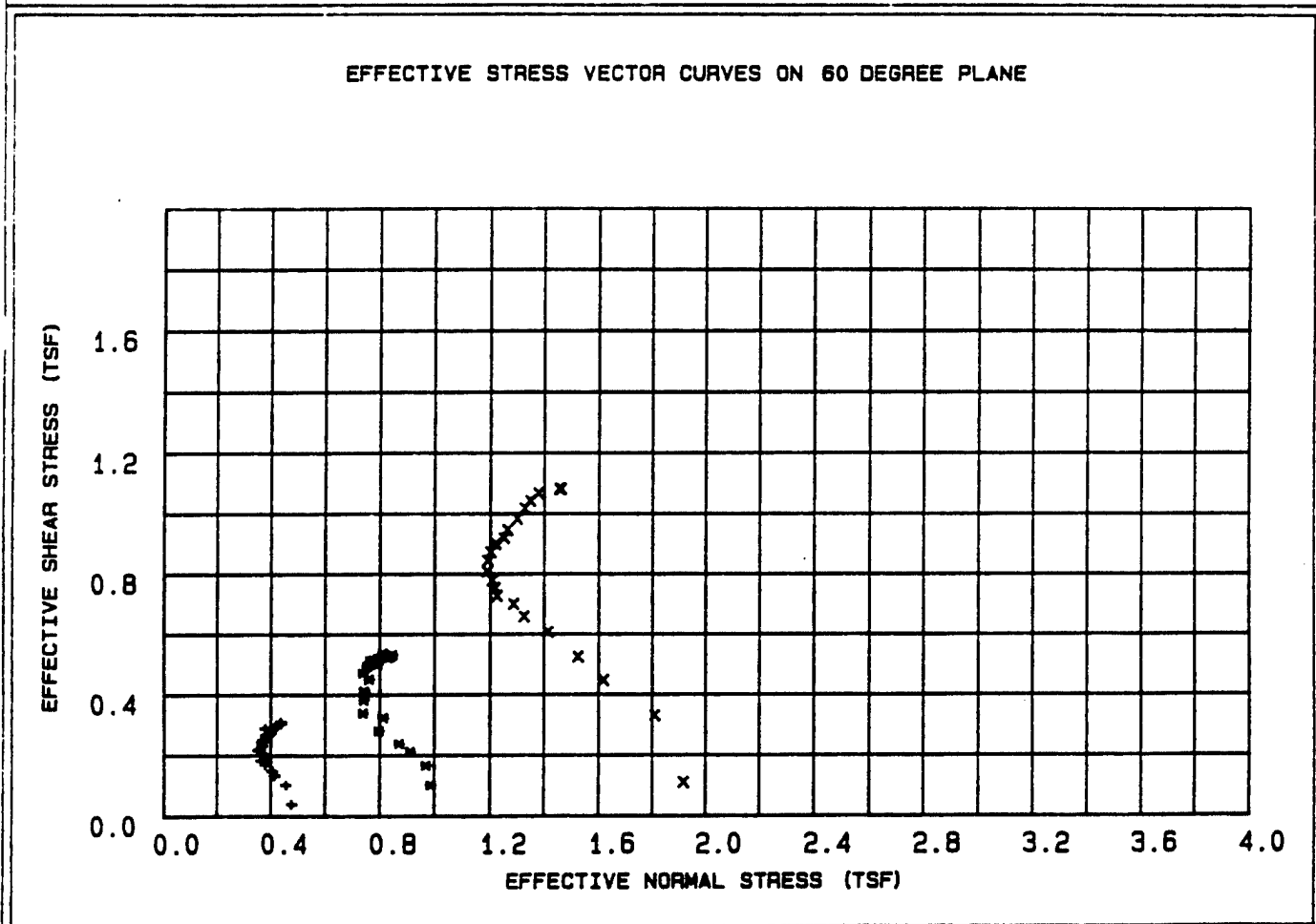
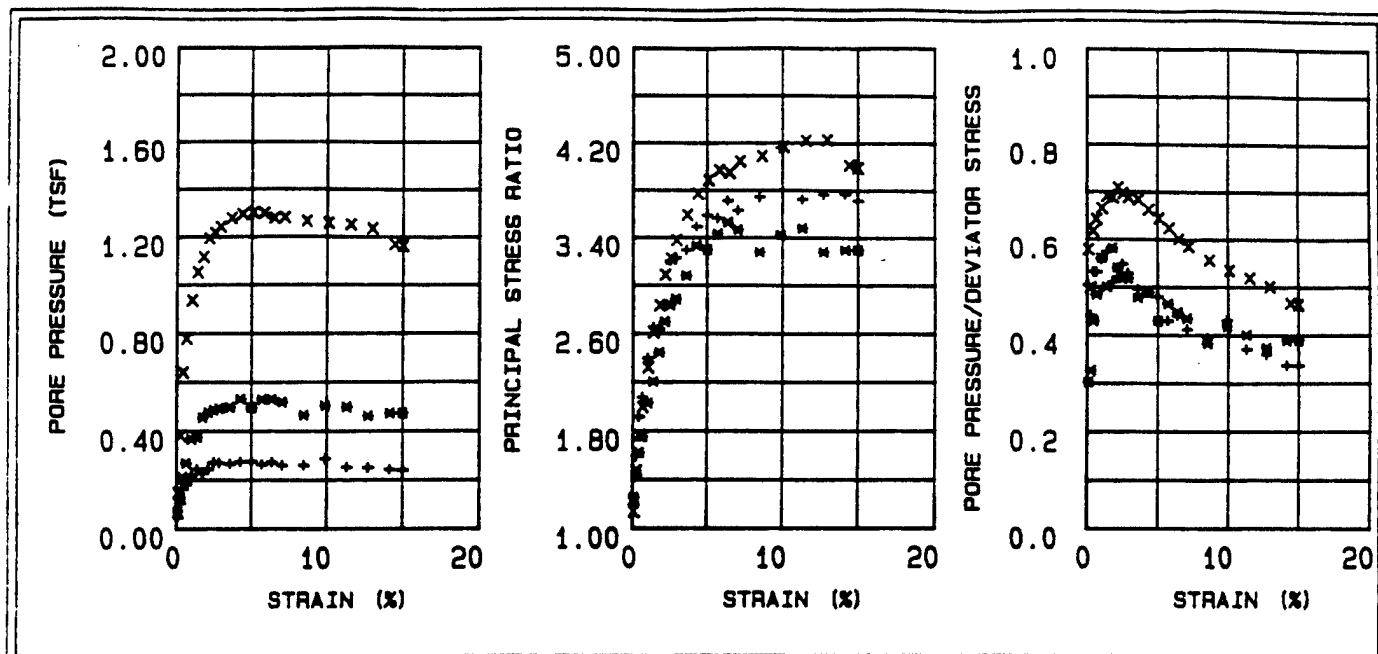
PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

FIGURE 5





<p style="text-align: center;"><b>LEGEND</b></p> <p>+ = .5 TSF</p> <p>x = 1 TSF</p> <p>x = 2 TSF</p>	<table> <tr> <td>PROJECT</td><td>MINNESOTA RIVER; IA-90-04-ED-GH</td></tr> <tr> <td>BORING NO.</td><td>89-130 MU</td></tr> <tr> <td>SAMPLE NO.</td><td>S-1</td></tr> <tr> <td>DEPTH/ELEV</td><td>4'-6'</td></tr> <tr> <td>MRD LAB NO.</td><td>90/135</td></tr> </table>	PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH	BORING NO.	89-130 MU	SAMPLE NO.	S-1	DEPTH/ELEV	4'-6'	MRD LAB NO.	90/135
PROJECT	MINNESOTA RIVER; IA-90-04-ED-GH										
BORING NO.	89-130 MU										
SAMPLE NO.	S-1										
DEPTH/ELEV	4'-6'										
MRD LAB NO.	90/135										

FIGURE 7

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-1  
 Depth : 4'-6'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.089	0.045	1.196	0.504	0.477	0.038
30	0.27	0.236	0.104	1.594	0.440	0.454	0.102
45	0.44	0.308	0.163	1.914	0.532	0.413	0.133
60	0.66	0.342	0.181	2.073	0.531	0.404	0.148
90	1.02	0.392	0.219	2.396	0.558	0.378	0.169
120	1.38	0.424	0.243	2.653	0.574	0.362	0.183
150	1.77	0.446	0.227	2.637	0.510	0.383	0.193
180	2.13	0.468	0.243	2.826	0.520	0.373	0.202
210	2.50	0.500	0.273	3.203	0.548	0.351	0.216
240	2.88	0.512	0.270	3.227	0.528	0.357	0.221
300	3.59	0.538	0.266	3.295	0.495	0.367	0.232
360	4.29	0.562	0.274	3.493	0.488	0.365	0.243
420	4.99	0.578	0.276	3.586	0.479	0.367	0.250
480	5.69	0.611	0.262	3.562	0.429	0.389	0.264
540	6.37	0.618	0.272	3.711	0.441	0.381	0.267
600	7.05	0.632	0.259	3.628	0.411	0.398	0.273
660	8.48	0.660	0.259	3.743	0.394	0.404	0.285
840	9.89	0.670	0.288	4.162	0.431	0.378	0.289
960	11.32	0.678	0.251	3.722	0.370	0.417	0.293
1080	12.72	0.694	0.249	3.763	0.359	0.423	0.300
1200	14.15	0.716	0.241	3.769	0.337	0.436	0.309
1267	15.00	0.710	0.238	3.712	0.336	0.437	0.306

Table 2 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-1  
 Depth : 4'-6'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.234	0.071	1.252	0.302	0.987	0.101
30	0.27	0.386	0.126	1.441	0.326	0.969	0.166
45	0.44	0.490	0.210	1.621	0.429	0.911	0.212
60	0.66	0.551	0.267	1.752	0.484	0.870	0.238
90	1.02	0.651	0.365	2.025	0.561	0.796	0.281
120	1.38	0.752	0.375	2.203	0.500	0.811	0.324
150	1.77	0.785	0.456	2.444	0.582	0.738	0.339
180	2.13	0.886	0.478	2.698	0.540	0.741	0.382
210	2.50	0.942	0.487	2.837	0.518	0.746	0.406
240	2.88	0.955	0.494	2.888	0.518	0.742	0.412
300	3.59	1.045	0.498	3.080	0.477	0.761	0.451
360	4.29	1.092	0.532	3.333	0.488	0.738	0.471
420	4.99	1.158	0.496	3.297	0.429	0.791	0.500
480	5.70	1.142	0.530	3.432	0.465	0.753	0.493
540	6.38	1.187	0.530	3.528	0.447	0.764	0.513
6	7.05	1.192	0.517	3.465	0.434	0.778	0.514
720	8.48	1.218	0.465	3.276	0.382	0.836	0.526
840	9.89	1.204	0.503	3.421	0.418	0.795	0.520
960	11.32	<del>1.246</del>	0.498	3.480	0.400	0.810	0.538
1080	12.73	1.230	0.460	3.277	0.374	0.845	0.531
1200	14.16	1.213	0.472	3.297	0.389	0.828	0.524
1267	15.00	1.213	0.472	3.296	0.390	0.828	0.523

Table 3 - Triaxial R Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-1  
 Depth : 4'-6'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.253	0.146	1.136	0.578	1.917	0.109
30	0.27	0.764	0.380	1.472	0.498	1.809	0.330
45	0.45	1.036	0.639	1.761	0.617	1.617	0.447
60	0.67	1.214	0.778	1.994	0.642	1.523	0.524
90	1.04	1.406	0.935	2.319	0.665	1.413	0.607
120	1.41	1.523	1.052	2.607	0.691	1.325	0.658
150	1.80	1.622	1.115	2.832	0.688	1.286	0.700
180	2.18	1.683	1.193	3.086	0.709	1.224	0.727
210	2.55	1.745	1.216	3.224	0.697	1.216	0.753
240	2.94	1.805	1.241	3.378	0.688	1.206	0.779
300	3.66	1.872	1.277	3.590	0.683	1.187	0.808
360	4.38	1.956	1.294	3.769	0.662	1.190	0.844
420	5.09	2.021	1.300	3.885	0.644	1.200	0.872
480	5.81	2.084	1.298	3.970	0.623	1.218	0.900
540	6.50	2.130	1.277	3.947	0.600	1.250	0.919
600	7.20	2.192	1.280	4.045	0.585	1.263	0.946
720	8.66	2.276	1.264	4.090	0.556	1.299	0.982
840	10.09	2.356	1.256	4.167	0.534	1.327	1.017
960	11.55	2.415	1.250	4.221	0.518	1.348	1.042
1080	12.98	2.472	1.234	4.225	0.500	1.378	1.067
1200	14.44	2.508	1.167	4.013	0.466	1.454	1.082
1243	15.00	2.508	1.161	3.989	0.463	1.461	1.082

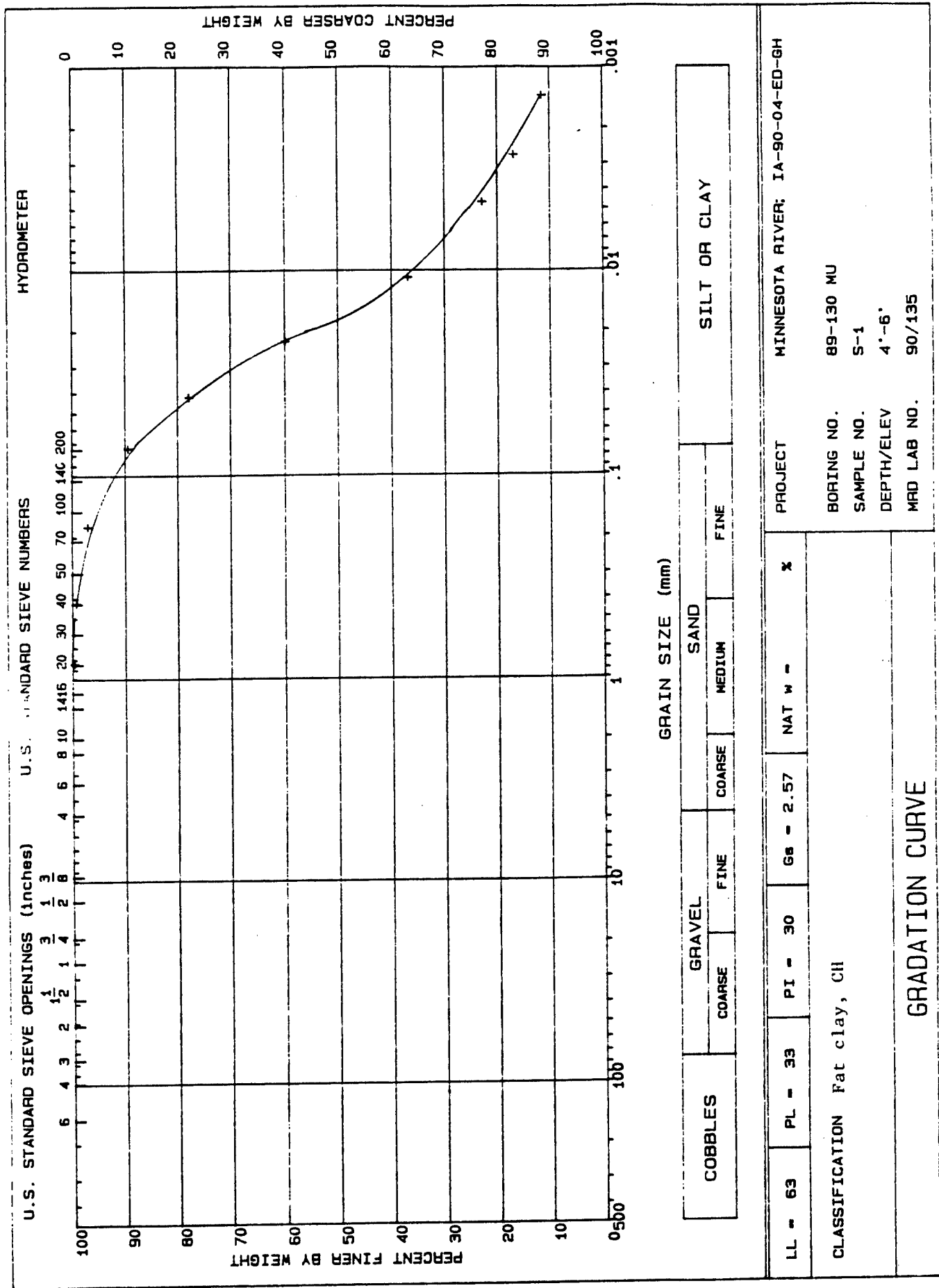
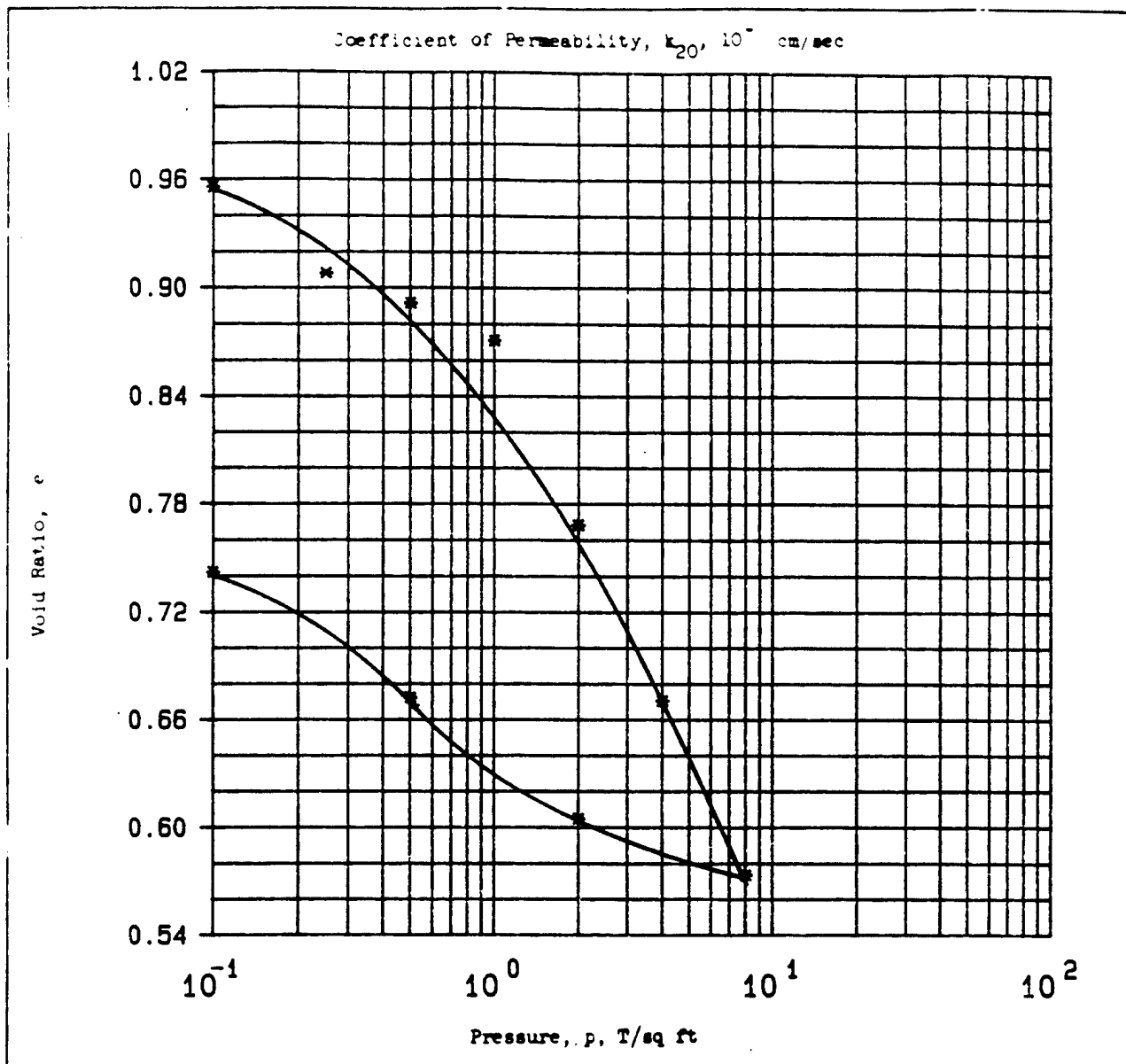
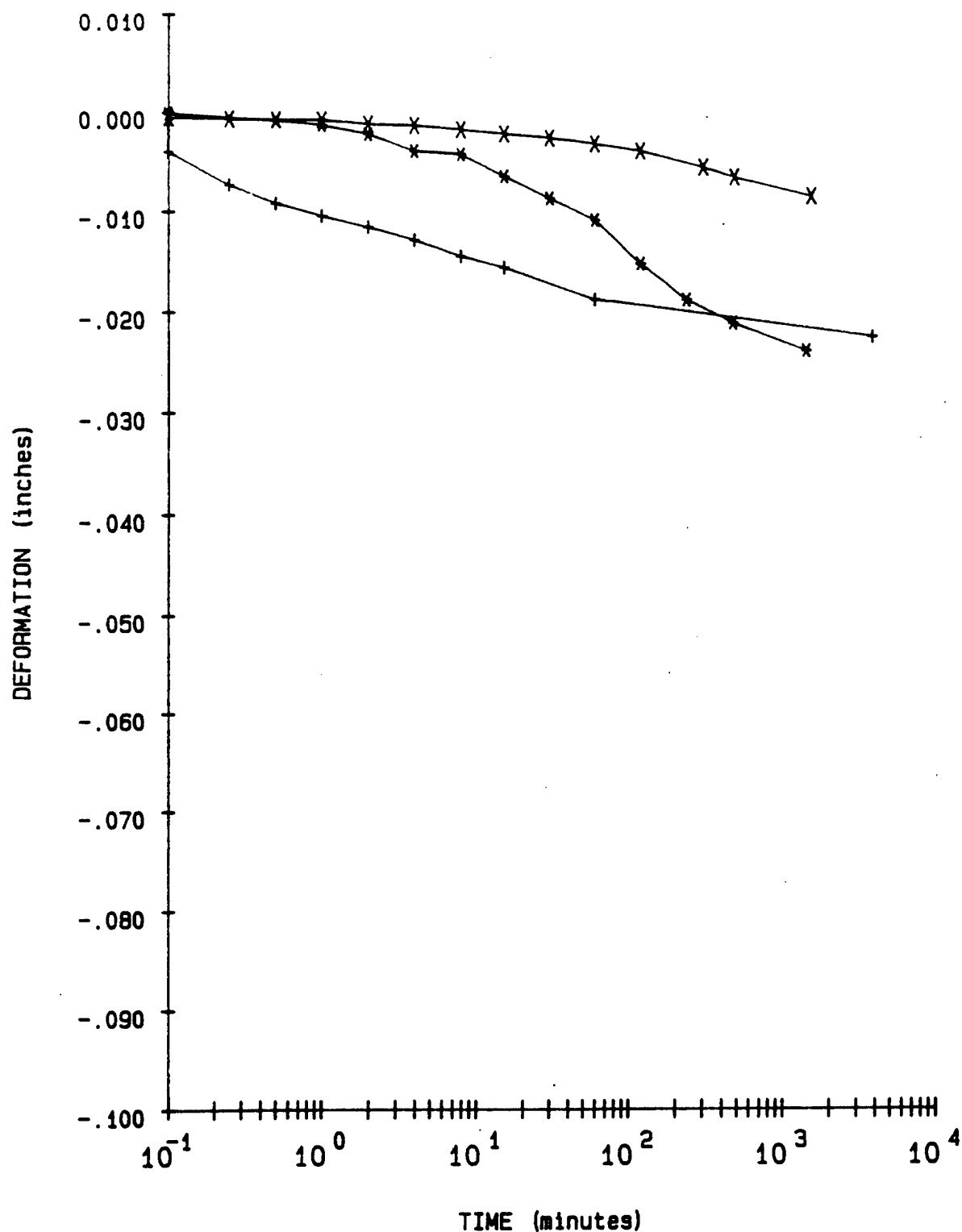


FIGURE 8





Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	1 in.	Water Content, $w_o$	37.4 %	$w_f$	24.2 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	1.00	$e_f$	0.74
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	99 %	$S_f$	86 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	82.7 lb/ft <sup>3</sup>		
Classification		Sandy clay, CL		$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec			
LL	41	$G_s$	2.65	Project			
PL	14	$D_{10}$					
Remarks				Area			
Dark gray. Torvane=0.30TSF				MRD LAB NO.      90/135			
Organic. Non-calcareous.				Boring No.      89-130 MU		Sample No.      S-2	
				Depth		Date	
				El		10'-12'	
				<b>CONSOLIDATION TEST REPORT</b>			



#### LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

#### PROJECT

MINNESOTA RIVER; IA-90-04-ED-6H

#### BORING NO.

89-130 MU

#### SAMPLE NO.

S-2

#### DEPTH/ELEV

10'-12'

#### MRD LAB NO.

90/135

FIGURE 2

Figure C-502

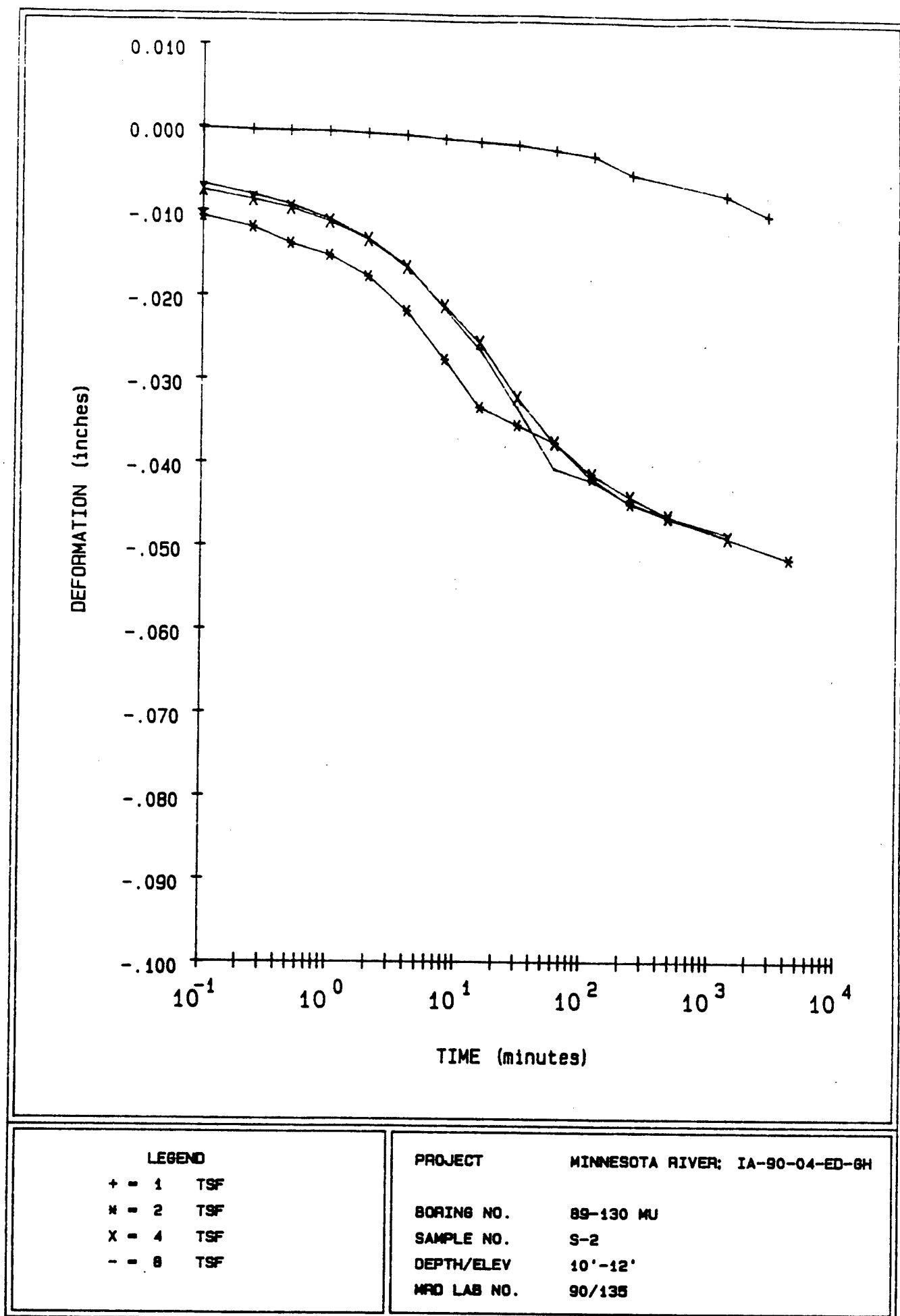
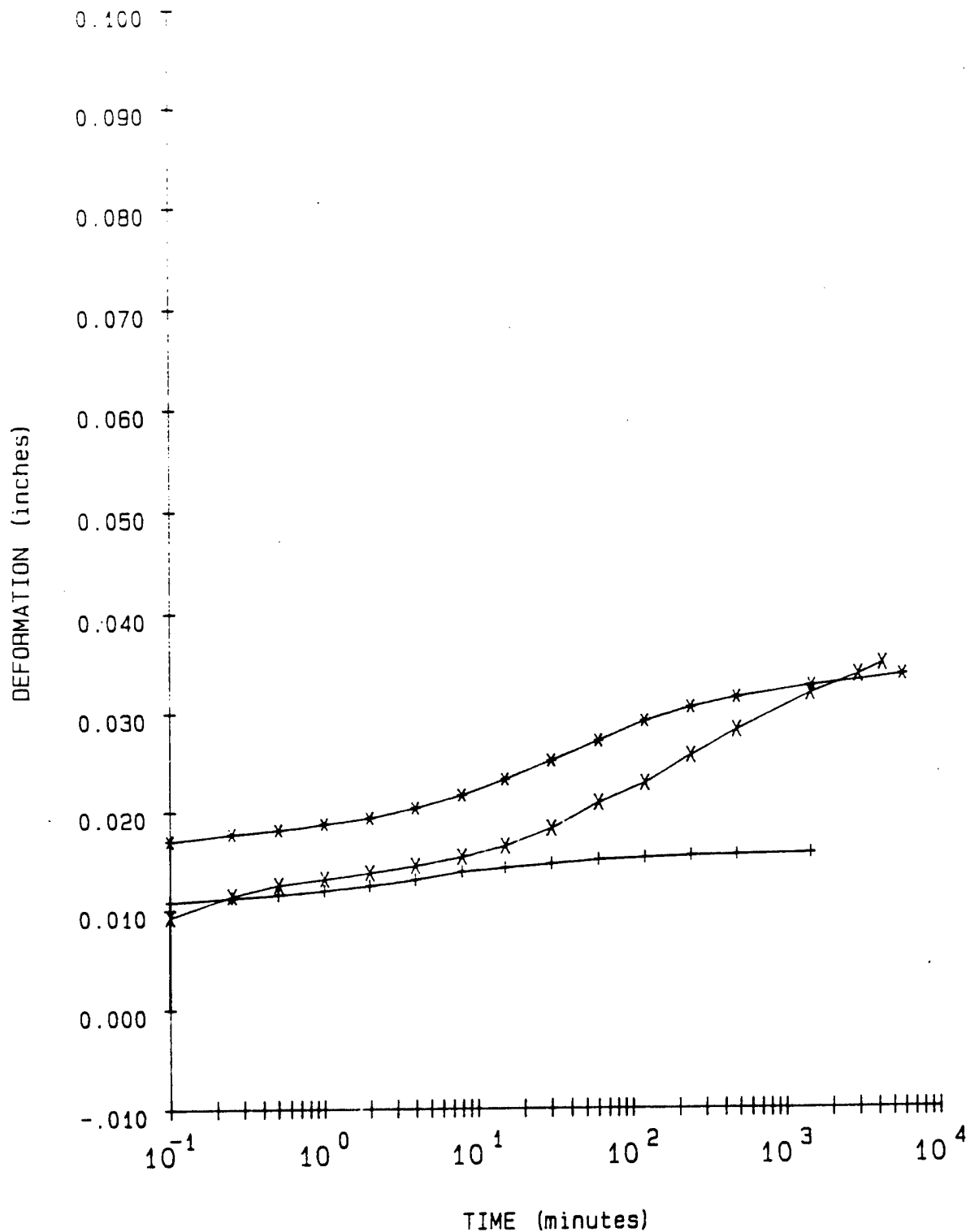


FIGURE 3



**LEGEND**

- + = 2 TSF Rebound
- \* = .5 TSF Rebound
- x = .1 TSF Rebound

**PROJECT**

MINNESOTA RIVER: IA-90-04-ED-GH

**BORING NO.**

89-130 MU

**SAMPLE NO.**

S-2

**DEPTH/ELEV**

10'-12'

**MRD LAB NO.**

90/135

**FIGURE 4**

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-130 MU

Sample No. S-2

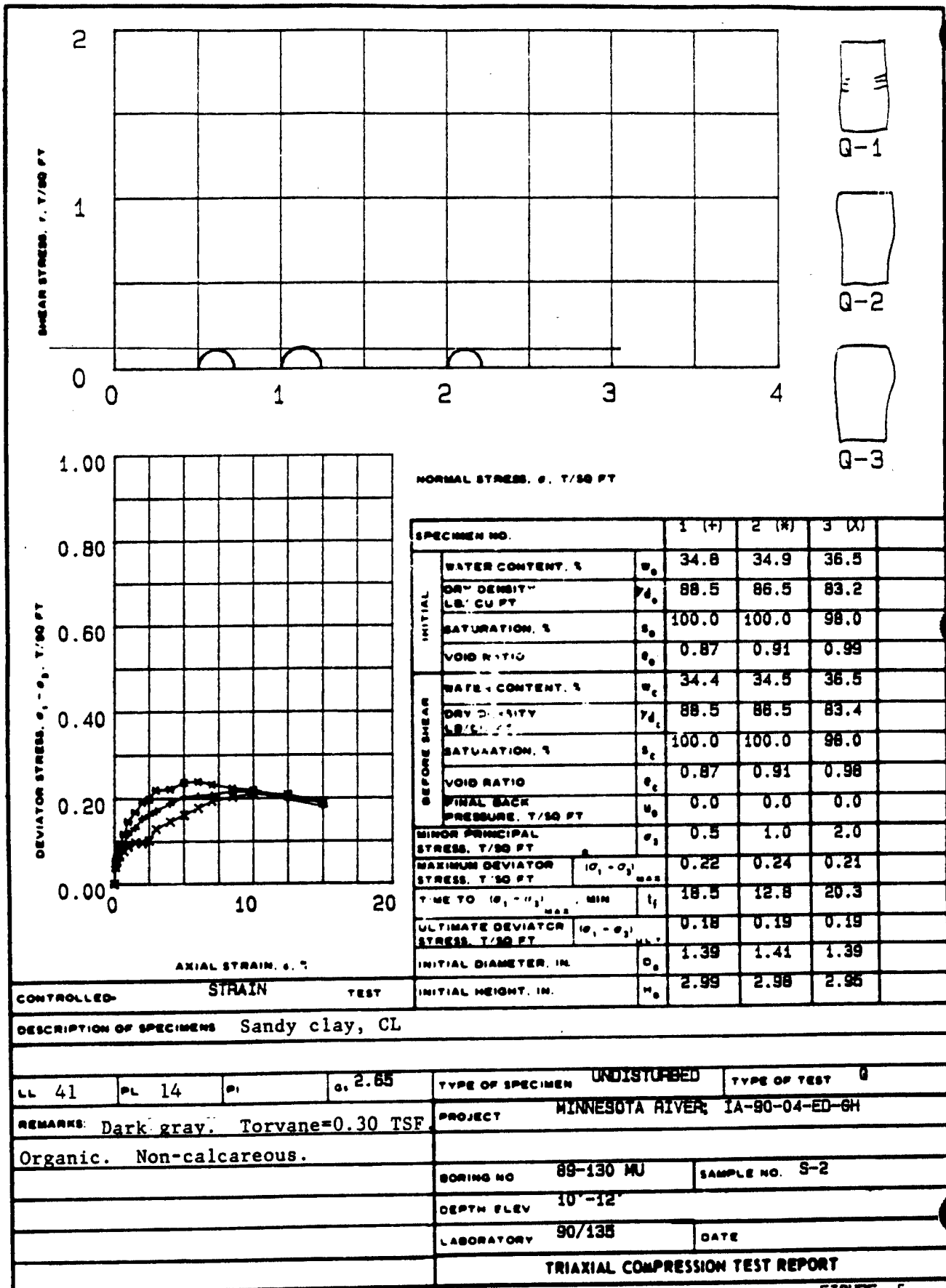
Depth/Elev 10'-12'

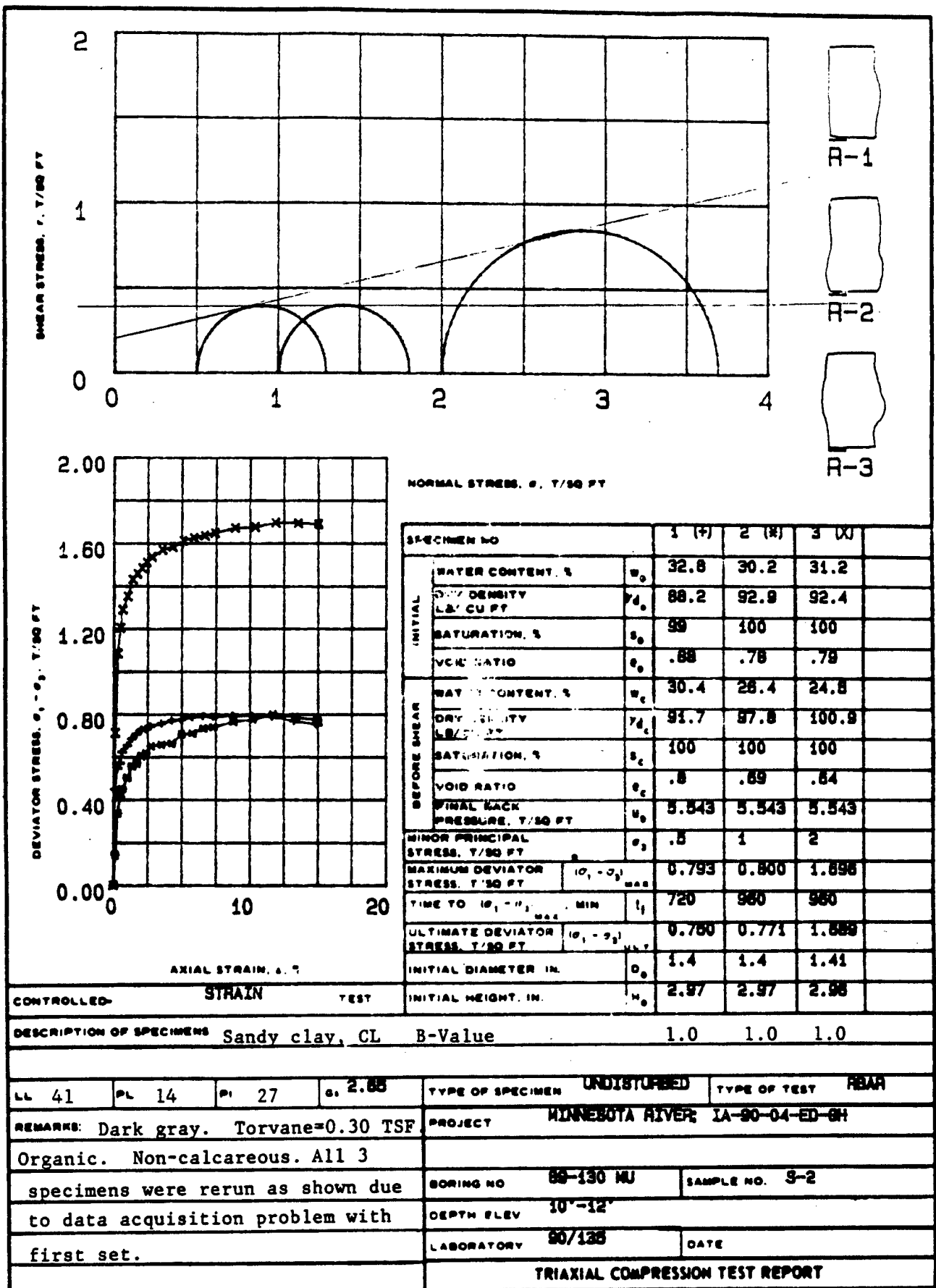
MRD Lab No. 90/135

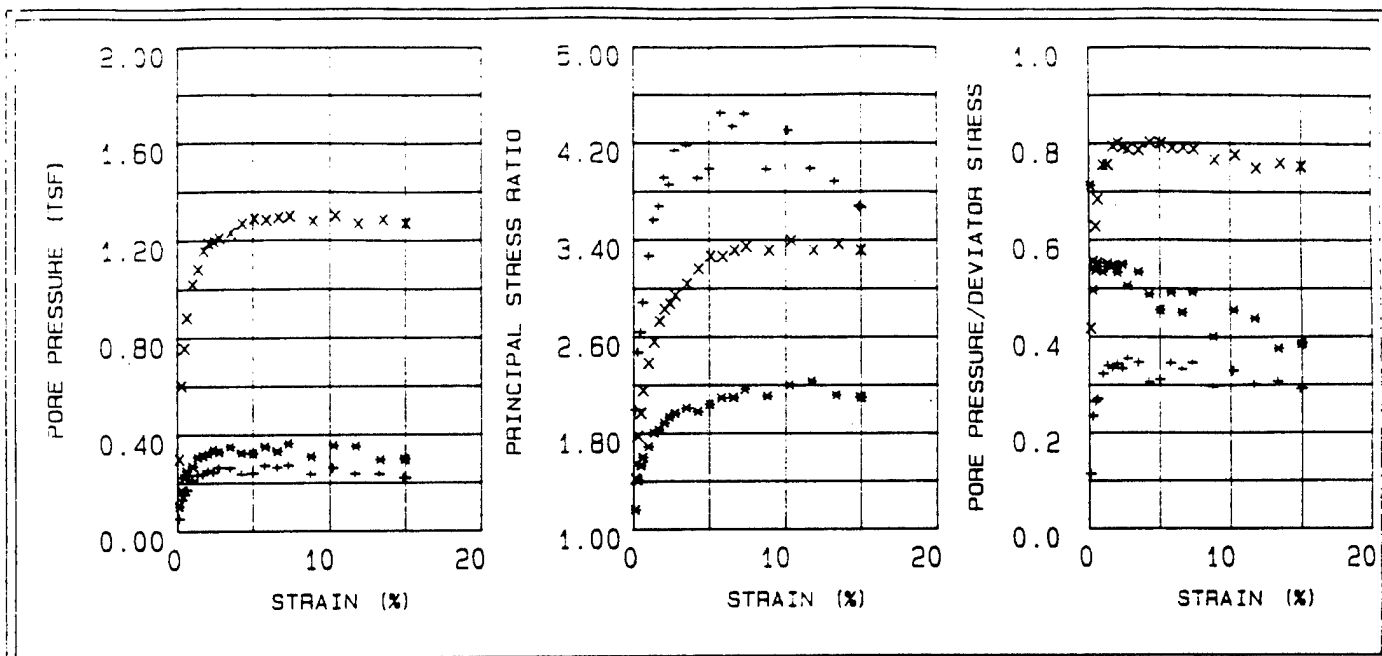
Gs = 2.65  
eo = 1.000  
0.42eo = 0.420

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
37.4	310.7	82.7	1.000		99.0
24.2	310.7	84.6	0.956	0.10	67.2
24.2	310.7	86.7	0.908	0.25	70.7
24.2	310.7	87.4	0.891	0.50	72.0
24.2	310.7	88.4	0.871	1.00	73.7
24.2	310.7	93.5	0.768	2.00	83.6
24.2	310.7	99.0	0.670	4.00	95.8
24.2	310.7	105.1	0.573	8.00	100.0
24.2	310.7	103.0	0.605	2.00	100.0
24.2	310.7	98.9	0.672	0.50	95.5
24.2	310.7	94.9	0.742	0.10	86.5

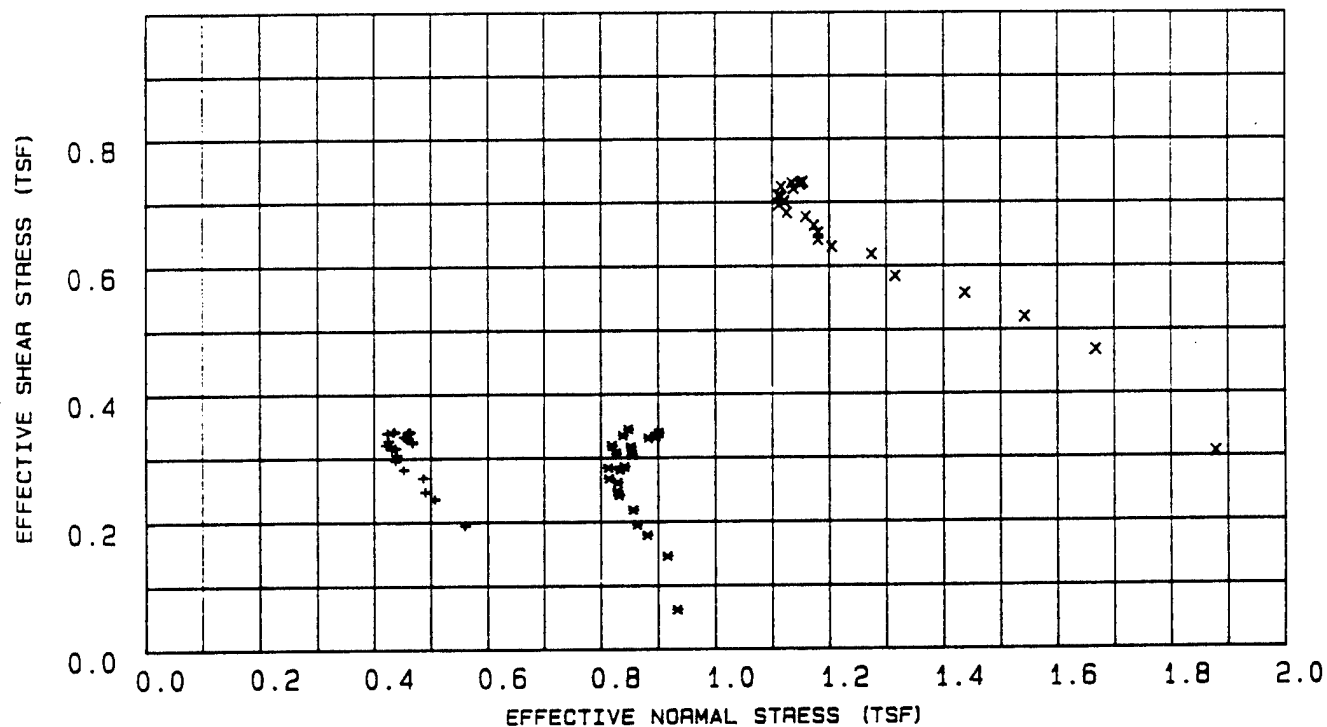
Axial Strain (%)	Void Ratio
1	0.980
2	0.960
3	0.940
4	0.920
5	0.900
6	0.880
7	0.860
8	0.840
9	0.820
10	0.800
11	0.780
12	0.760
13	0.740
14	0.720
15	0.700
16	0.680
17	0.660
18	0.640
19	0.620
20	0.600







EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

- + = .5 TSF
- \* = 1 TSF
- x = 2 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-2

DEPTH/ELEV

10'-12'

MRO LAB NO.

90/135

FIGURE 7

Figure C-508



Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-2  
 Depth : 10'-12'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.449	0.051	1.999	0.114	0.560	0.194
30	0.29	0.547	0.129	2.473	0.236	0.506	0.236
45	0.48	0.571	0.152	2.640	0.266	0.489	0.247
60	0.63	0.624	0.169	2.885	0.271	0.485	0.269
90	1.00	0.654	0.211	3.266	0.323	0.451	0.282
120	1.33	0.685	0.233	3.566	0.340	0.437	0.296
150	1.67	0.707	0.236	3.679	0.335	0.439	0.305
180	2.01	0.728	0.250	3.916	0.344	0.430	0.314
210	2.35	0.732	0.244	3.855	0.334	0.437	0.316
240	2.71	0.743	0.263	4.139	0.355	0.421	0.321
300	3.47	0.757	0.262	4.183	0.347	0.425	0.327
360	4.22	0.771	0.235	3.909	0.305	0.456	0.333
420	4.97	0.775	0.240	3.986	0.311	0.452	0.334
480	5.74	0.787	0.272	4.451	0.346	0.423	0.340
540	6.52	0.791	0.263	4.339	0.333	0.433	0.341
600	7.27	0.786	0.272	4.444	0.347	0.423	0.339
720	8.73	0.793	0.234	3.981	0.296	0.462	0.342
840	10.18	0.791	0.261	4.311	0.330	0.435	0.342
960	11.63	0.789	0.236	3.989	0.300	0.459	0.340
1080	13.25	0.767	0.234	3.882	0.306	0.456	0.331
1200	14.83	0.753	0.219	3.678	0.291	0.467	0.325
1213	15.00	0.750	0.219	3.666	0.292	0.466	0.324

Table 2 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-2  
 Depth : 10'-12'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.144	0.103	1.161	0.713	0.933	0.062
30	0.29	0.338	0.168	1.407	0.496	0.916	0.146
45	0.49	0.414	0.222	1.532	0.537	0.881	0.179
60	0.63	0.451	0.249	1.601	0.553	0.863	0.195
90	1.00	0.504	0.269	1.690	0.534	0.856	0.218
120	1.34	0.557	0.307	1.804	0.551	0.831	0.241
150	1.68	0.571	0.312	1.831	0.547	0.829	0.247
180	2.02	0.605	0.321	1.891	0.532	0.829	0.261
210	2.37	0.618	0.339	1.936	0.549	0.814	0.267
240	2.73	0.651	0.328	1.969	0.505	0.833	0.281
300	3.49	0.657	0.350	2.011	0.533	0.813	0.284
360	4.24	0.664	0.323	1.980	0.487	0.841	0.286
420	5.00	0.707	0.321	2.042	0.455	0.854	0.305
480	5.78	0.712	0.350	2.096	0.492	0.826	0.307
5/	6.56	0.735	0.330	2.098	0.450	0.852	0.317
600	7.31	0.740	0.364	2.164	0.493	0.819	0.319
720	8.78	0.767	0.307	2.107	0.400	0.883	0.331
840	10.24	0.776	0.354	2.200	0.456	0.838	0.335
960	11.70	0.800	0.350	2.232	0.438	0.848	0.345
1080	13.33	0.786	0.294	2.114	0.375	0.901	0.339
1200	14.92	0.772	0.296	2.097	0.384	0.895	0.333
1206	15.00	0.771	0.297	2.096	0.386	0.894	0.333

Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-2  
 Depth : 10'-12'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.13	0.712	0.297	1.418	0.417	1.879	0.307
30	0.30	1.084	0.601	1.775	0.555	1.667	0.468
45	0.49	1.205	0.756	1.969	0.628	1.542	0.520
60	0.64	1.290	0.882	2.154	0.684	1.437	0.557
90	1.01	1.353	1.020	2.381	0.755	1.315	0.584
120	1.36	1.433	1.081	2.559	0.755	1.274	0.618
150	1.71	1.459	1.157	2.731	0.794	1.204	0.630
180	2.05	1.486	1.188	2.830	0.800	1.180	0.641
210	2.40	1.512	1.194	2.877	0.791	1.180	0.652
240	2.77	1.537	1.208	2.942	0.787	1.173	0.663
300	3.53	1.569	1.230	3.038	0.785	1.158	0.677
360	4.30	1.583	1.267	3.160	0.801	1.125	0.683
420	5.07	1.613	1.288	3.264	0.799	1.111	0.696
480	5.86	1.625	1.281	3.261	0.789	1.121	0.701
540	6.65	1.636	1.292	3.312	0.790	1.113	0.706
600	7.41	1.648	1.297	3.344	0.787	1.111	0.711
720	8.90	1.671	1.277	3.311	0.765	1.137	0.721
840	10.38	1.676	1.300	3.395	0.776	1.115	0.724
960	11.86	1.696	1.267	3.315	0.748	1.153	0.732
1080	13.52	1.693	1.285	3.366	0.759	1.134	0.730
1190	15.00	1.689	1.270	3.315	0.753	1.148	0.729
1190	15.00	1.689	1.270	3.315	0.753	1.148	0.729

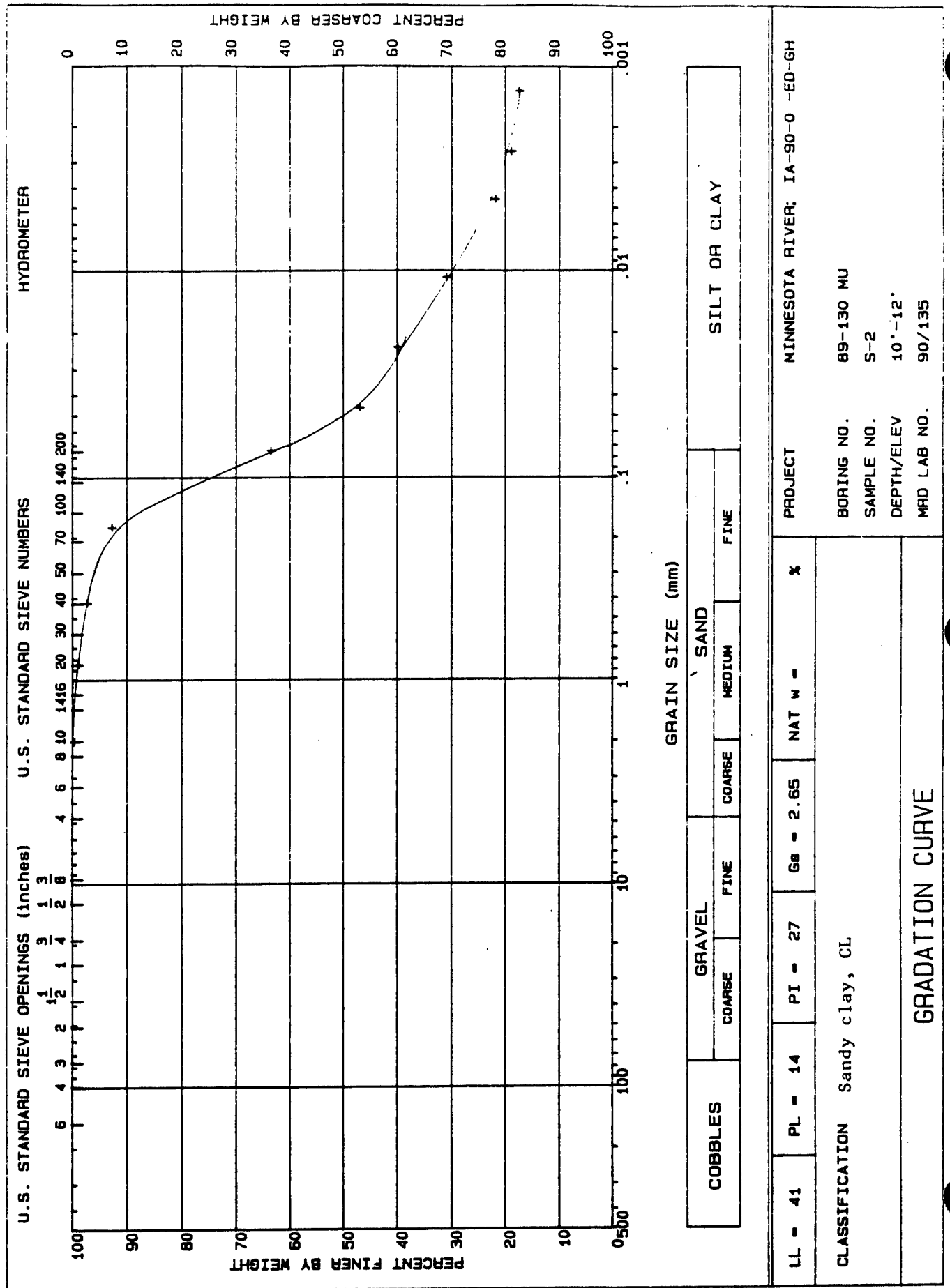
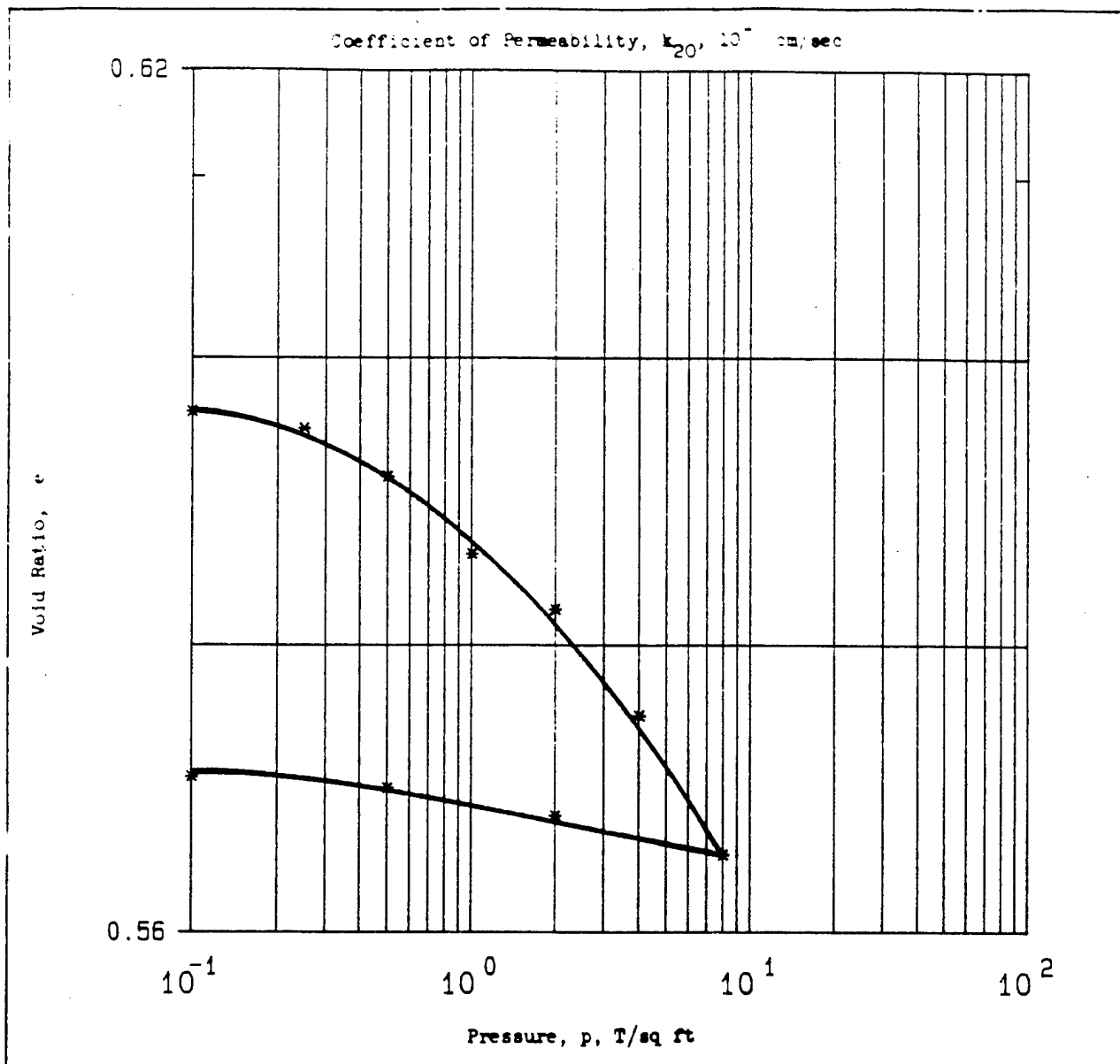


Figure C-512



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.3 in.	Ht	.997 in.	Water Content, $w_o$	21.3 %	$w_f$	21.9 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	0.61	$e_f$	0.57
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	95 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	105.3 lb/ft <sup>3</sup>		
Classification Silt, ML-CL				$k_{20}$ at $e_o =$ $\times 10^{-7}$ cm/sec			
LL	24	$G_s$	2.72	Project			
PL	19	$D_{10}$					
Remarks		Medium gray. Torvane=0.7		Area			
TSF. Slightly calcareous.				MRD LAB NO.		90/135	
				Boring No.		89-130 MU	
				Sample No.		S-3	
				Depth		21'-22.8'	
				Date			
<b>CONSOLIDATION TEST REPORT</b>							

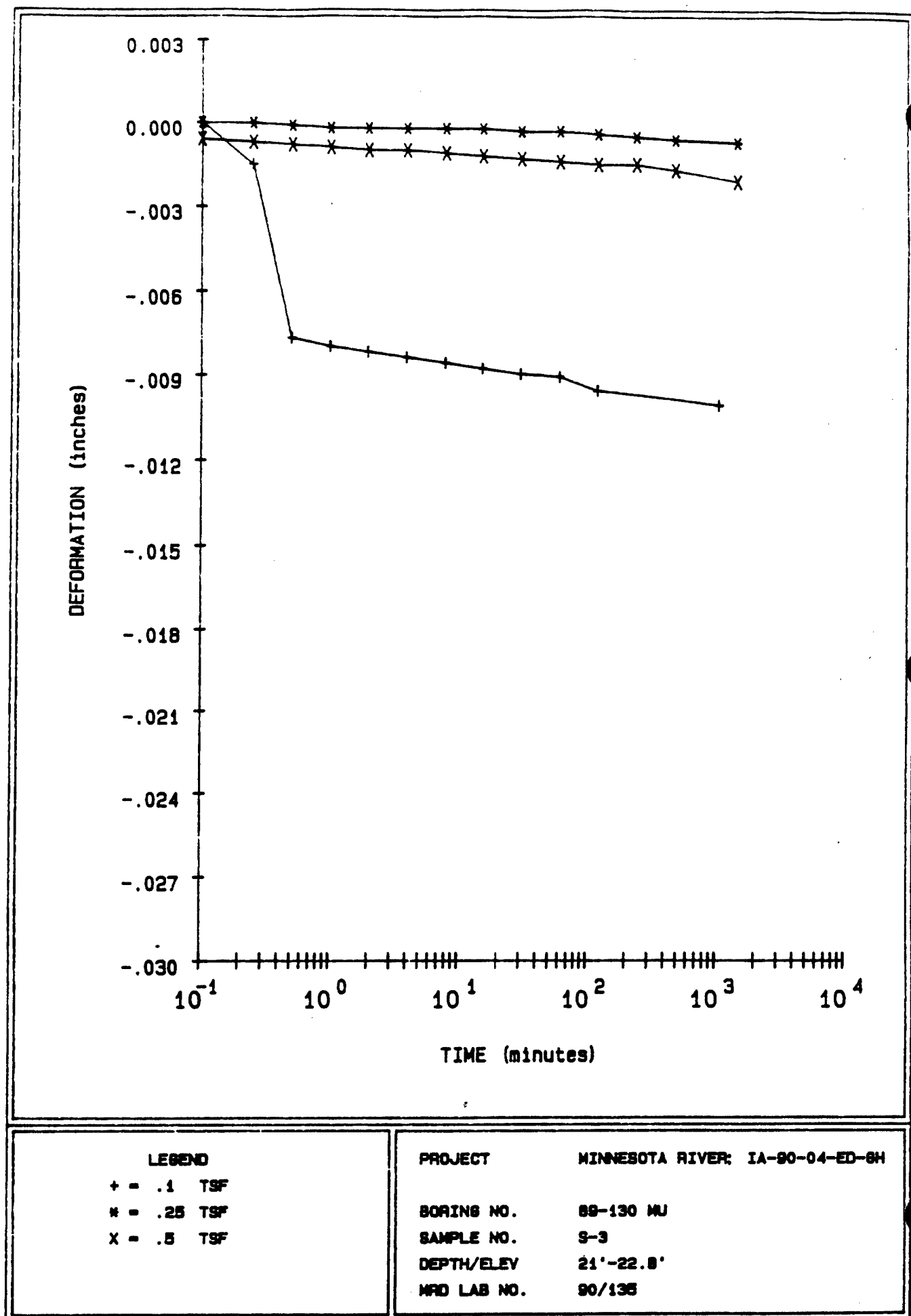
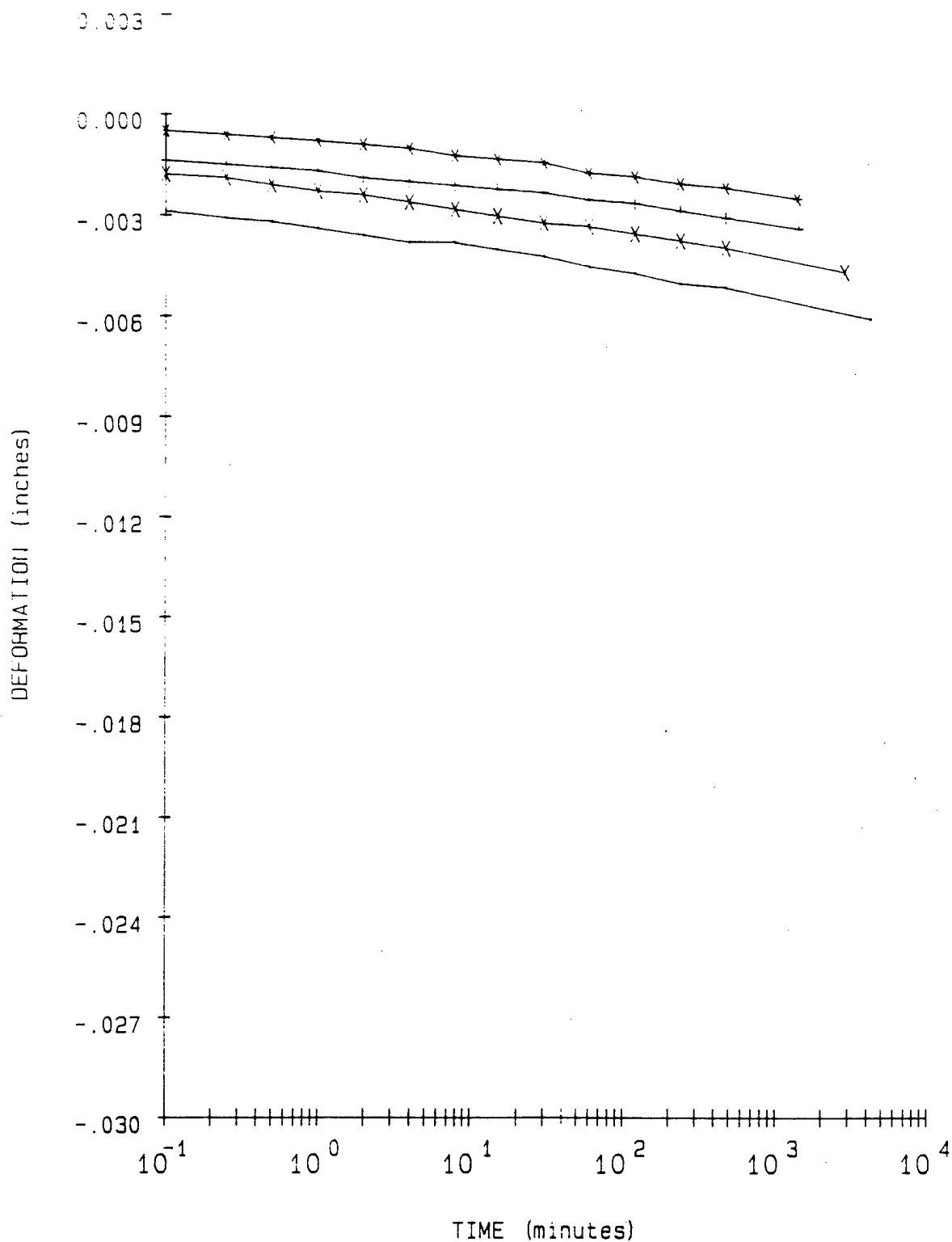


FIGURE 2  
Figure C-514



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-3

DEPTH/ELEV

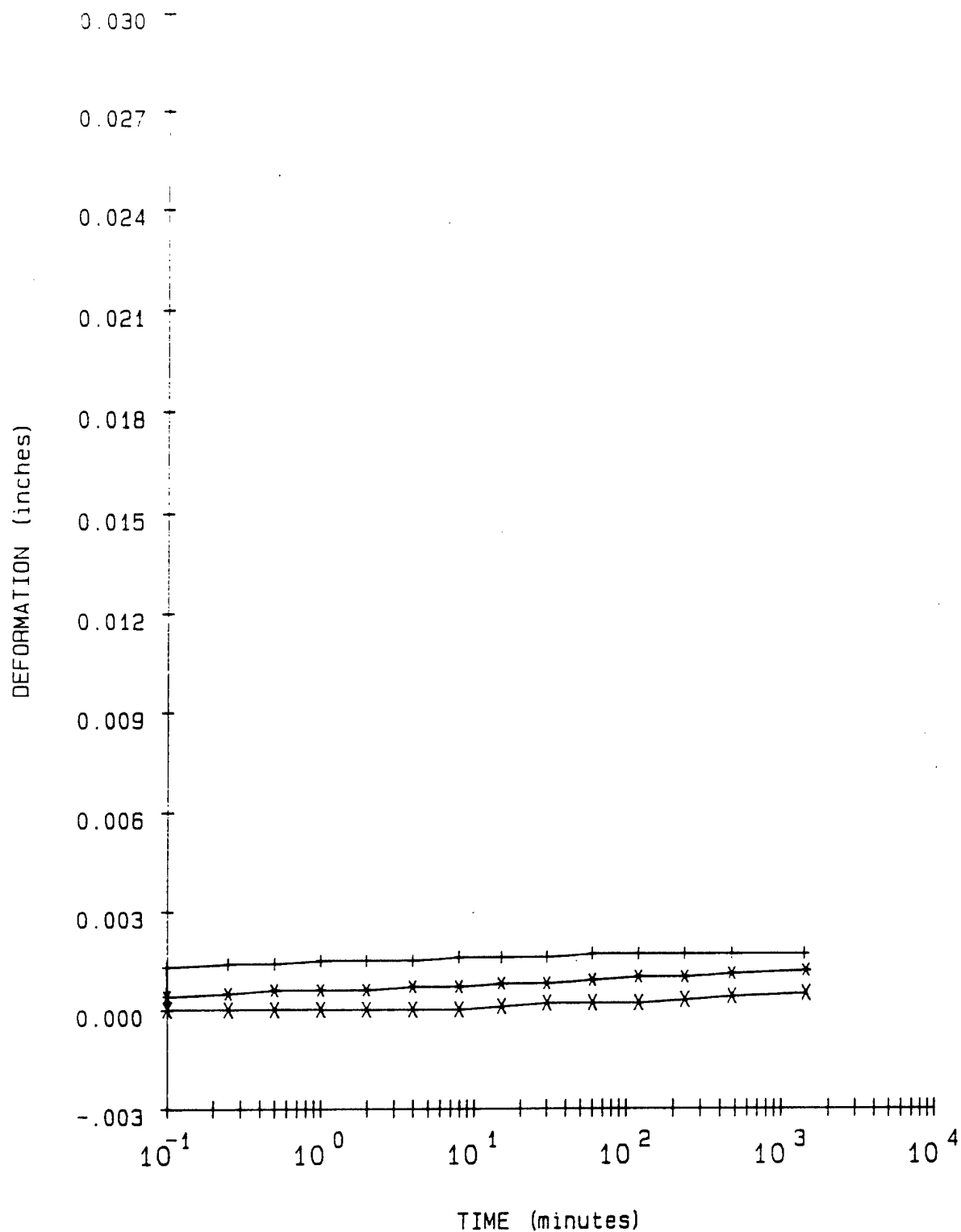
21'-22.8'

MRD LAB NO.

90/135

FIGURE 3

Figure C-515



LEGEND

+ = 2 TSF  
 \* = .5 TSF  
 x = .1 TSF

PROJECT MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO. 89-130 MU

SAMPLE NO. S-3

DEPTH/ELEV 21'-22.8'

MWD LAB NO. 90/135

FIGURE 4  
 Figure C-516



# Consolidation Test Data ---

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-130 MU

Sample No. S-3

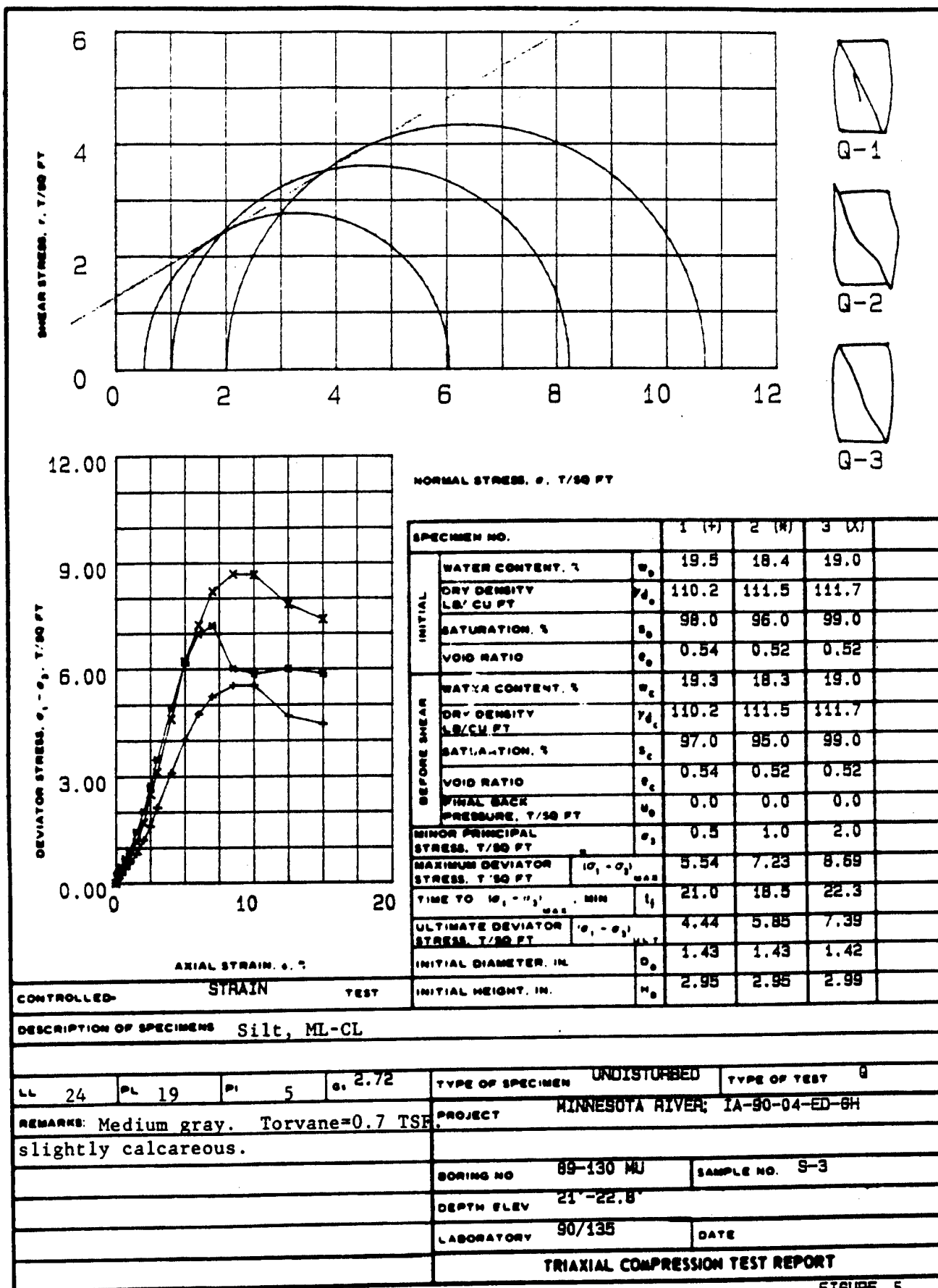
Depth/Elev 21'-22.8'

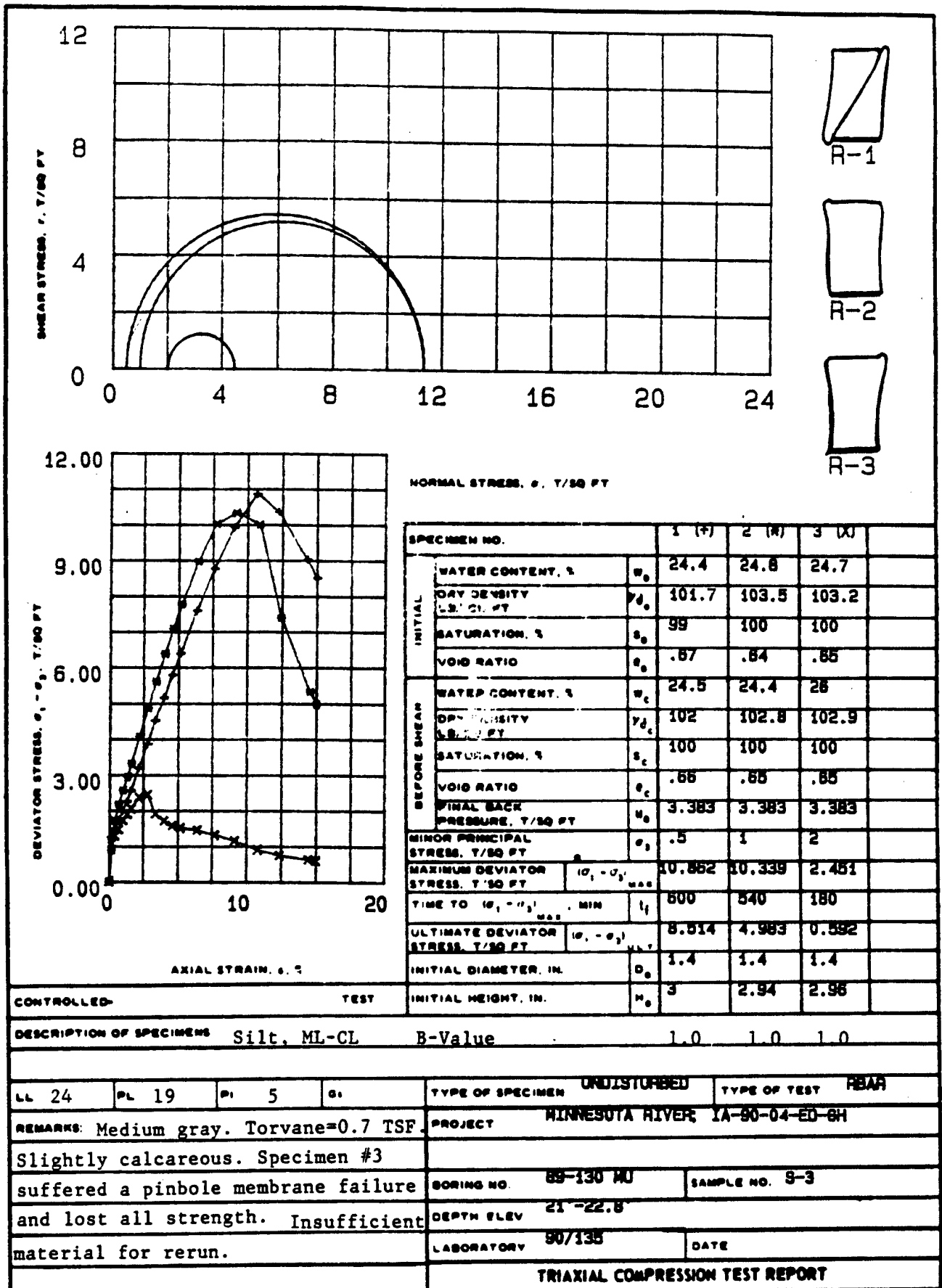
MRD Lab No. 90/135

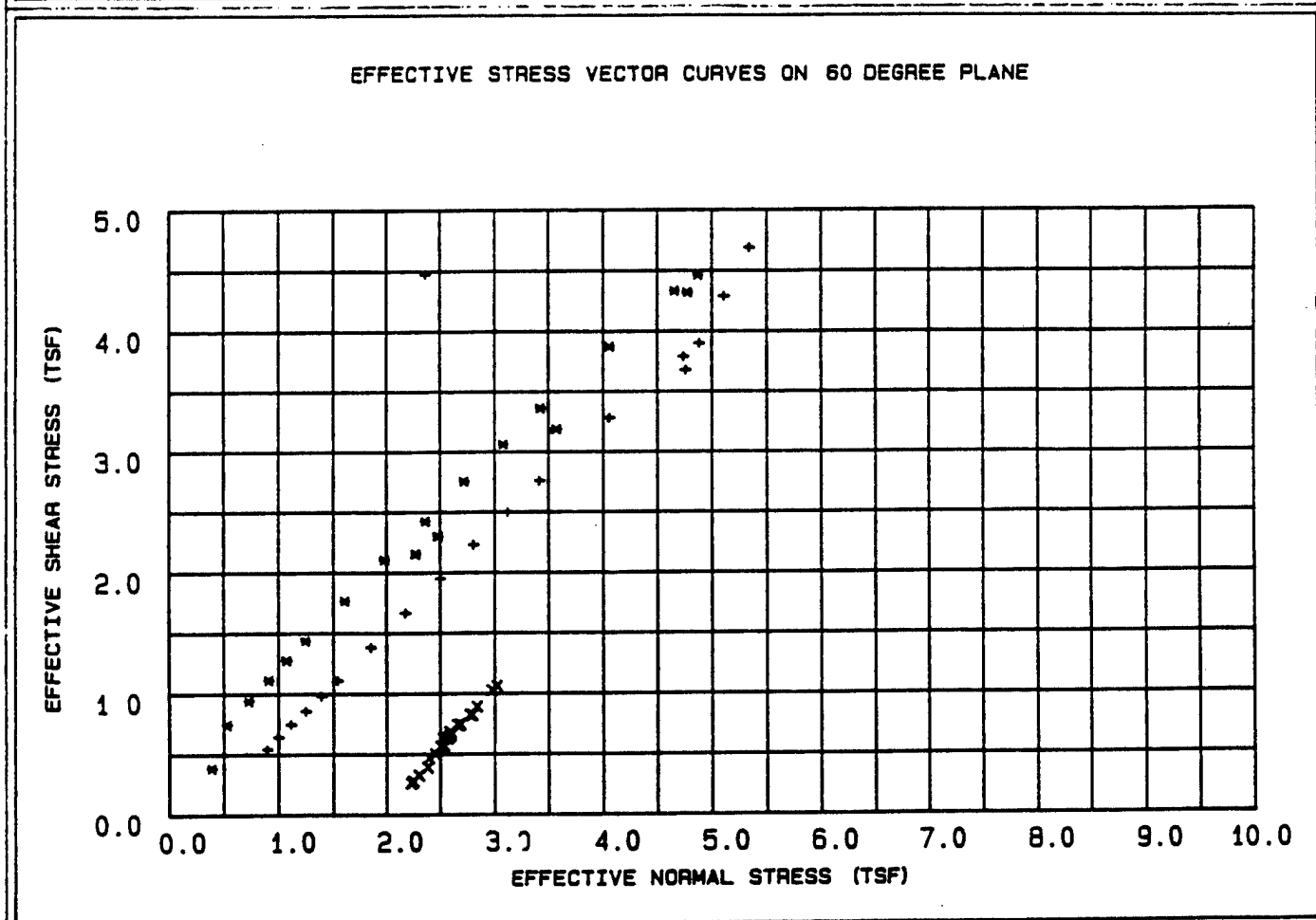
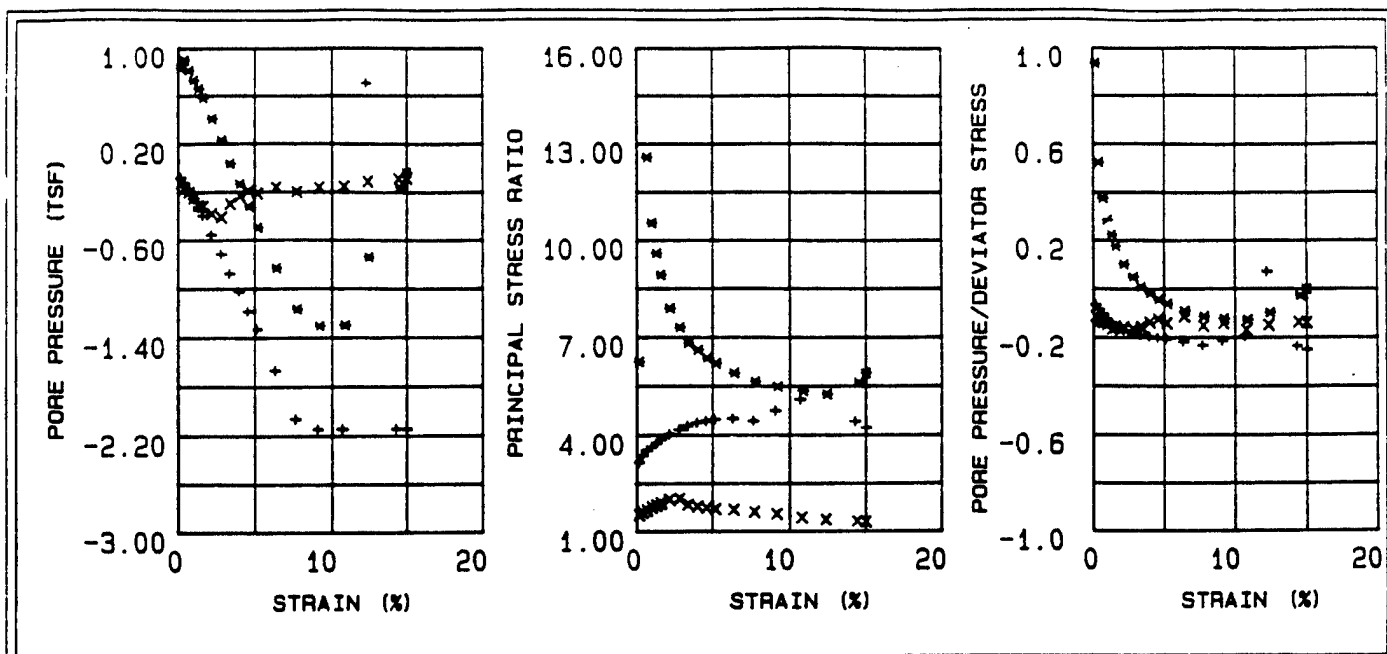
Gs = 2.72  
eo = 0.613  
0.42eo = 0.257

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
21.3	398.7	105.3	0.613		94.7
21.9	398.7	106.3	0.596	0.10	100.0
21.9	398.7	106.4	0.595	0.25	100.0
21.9	398.7	106.6	0.592	0.50	100.0
21.9	398.7	107.0	0.586	1.00	100.0
21.9	398.7	107.3	0.582	2.00	100.0
21.9	398.7	107.8	0.575	4.00	100.0
21.9	398.7	108.4	0.565	8.00	100.0
21.9	398.7	108.2	0.568	2.00	100.0
21.9	398.7	108.1	0.570	0.50	100.0
21.9	398.7	108.0	0.571	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.596
2	0.580
3	0.564
4	0.548
5	0.532







<p style="text-align: center;"><b>LEGEND</b></p> <p>+ = .5 TSF</p> <p>* = 1 TSF</p> <p>x = 2 TSF</p>		<p><b>PROJECT</b>                      MINNESOTA RIVER: IA-90-04-ED-GH</p>	
<p><b>BORING NO.</b>                      89-130 MU</p>		<p><b>SAMPLE NO.</b>                      S-3</p>	
<p><b>DEPTH/ELEV</b>                      21'-22.8'</p>		<p><b>MRD LAB NO.</b>                      90/135</p>	

**FIGURE 7**  
Figure C-520

Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-3  
 Depth : 21'-22.8'  
 Confining Pressure : .5 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.17	1.254	-0.083	3.151	-0.066	0.893	0.541
30	0.40	1.484	-0.129	3.361	-0.086	0.996	0.641
45	0.69	1.730	-0.183	3.531	-0.106	1.111	0.747
60	1.00	1.982	-0.255	3.625	-0.128	1.246	0.855
90	1.31	2.267	-0.327	3.743	-0.144	1.388	0.978
120	1.59	2.568	-0.401	3.850	-0.156	1.537	1.109
150	2.16	3.200	-0.560	4.020	-0.174	1.852	1.381
180	2.80	3.863	-0.719	4.168	-0.186	2.175	1.667
210	3.34	4.523	-0.879	4.280	-0.194	2.499	1.952
240	3.96	5.162	-1.029	4.375	-0.199	2.807	2.228
300	4.53	5.787	-1.189	4.426	-0.205	3.122	2.498
360	5.13	6.394	-1.336	4.482	-0.208	3.419	2.760
420	6.31	7.601	-1.673	4.498	-0.220	4.055	3.281
	7.64	8.776	-2.067	4.419	-0.235	4.740	3.788
540	9.06	9.934	-2.149	4.750	-0.216	5.108	4.288
600	10.68	10.862	-2.149	5.100	-0.197	5.338	4.688
720	12.22	10.359	0.706	%-49.294	0.069	2.359	4.471
840	14.29	9.027	-2.149	4.408	-0.238	4.884	3.896
895	15.00	8.514	-2.149	4.214	-0.253	4.757	3.675

Table 2 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-3  
 Depth : 21'-22.8'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.17	0.889	0.831	6.250	0.935	0.389	0.384
30	0.41	1.723	0.901	18.456	0.523	0.526	0.744
45	0.70	2.180	0.812	12.571	0.373	0.728	0.941
60	1.01	2.578	0.729	10.522	0.283	0.909	1.113
90	1.33	2.955	0.656	9.582	0.222	1.075	1.275
120	1.62	3.330	0.579	8.914	0.174	1.245	1.437
150	2.20	4.092	0.406	7.886	0.100	1.607	1.766
180	2.85	4.876	0.225	7.292	0.047	1.982	2.105
210	3.40	5.621	0.032	6.808	0.006	2.360	2.426
240	4.03	6.386	-0.140	6.604	-0.021	2.721	2.756
300	4.61	7.092	-0.326	6.347	-0.046	3.082	3.061
360	5.22	7.786	-0.501	6.186	-0.064	3.429	3.361
420	6.42	8.971	-0.835	5.889	-0.093	4.056	3.872
480	7.78	10.036	-1.170	5.624	-0.116	4.655	4.332
54	9.22	10.339	-1.311	5.473	-0.126	4.871	4.462
60	10.87	<del>10.001</del>	<del>-1.301</del>	5.346	-0.130	4.777	4.317
720	12.44	7.382	-0.741	5.240	-0.100	3.569	3.186
840	14.54	5.326	-0.159	5.596	-0.029	2.478	2.299
875	15.00	4.983	-0.037	5.888	-0.002	2.271	2.151

Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-3  
 Depth : 21'-22.8'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.17	1.085	-0.125	1.511	-0.114	2.394	0.468
30	0.41	1.300	-0.176	1.598	-0.135	2.498	0.561
45	0.70	1.463	-0.206	1.663	-0.140	2.568	0.631
60	1.01	1.725	-0.256	1.764	-0.148	2.683	0.744
90	1.32	1.901	-0.319	1.820	-0.167	2.790	0.820
120	1.61	2.059	-0.326	1.885	-0.158	2.836	0.889
150	2.18	2.374	-0.384	1.996	-0.161	2.972	1.025
180	2.83	2.451	-0.415	2.015	-0.169	3.022	1.058
210	3.38	1.904	-0.301	1.827	-0.158	2.772	0.822
240	4.00	1.704	-0.236	1.762	-0.138	2.658	0.736
300	4.58	1.574	-0.198	1.716	-0.125	2.588	0.679
360	5.18	1.508	-0.216	1.681	-0.143	2.589	0.651
420	6.38	1.444	-0.166	1.666	-0.115	2.523	0.623
480	7.72	1.313	-0.204	1.596	-0.155	2.529	0.567
540	9.16	1.152	-0.166	1.532	-0.144	2.451	0.497
600	10.79	0.899	-0.155	1.417	-0.171	2.378	0.388
720	12.35	0.745	-0.113	1.353	-0.151	2.298	0.322
840	14.43	0.630	-0.088	1.302	-0.139	2.244	0.272
883	15.00	0.592	-0.084	1.284	-0.141	2.230	0.256

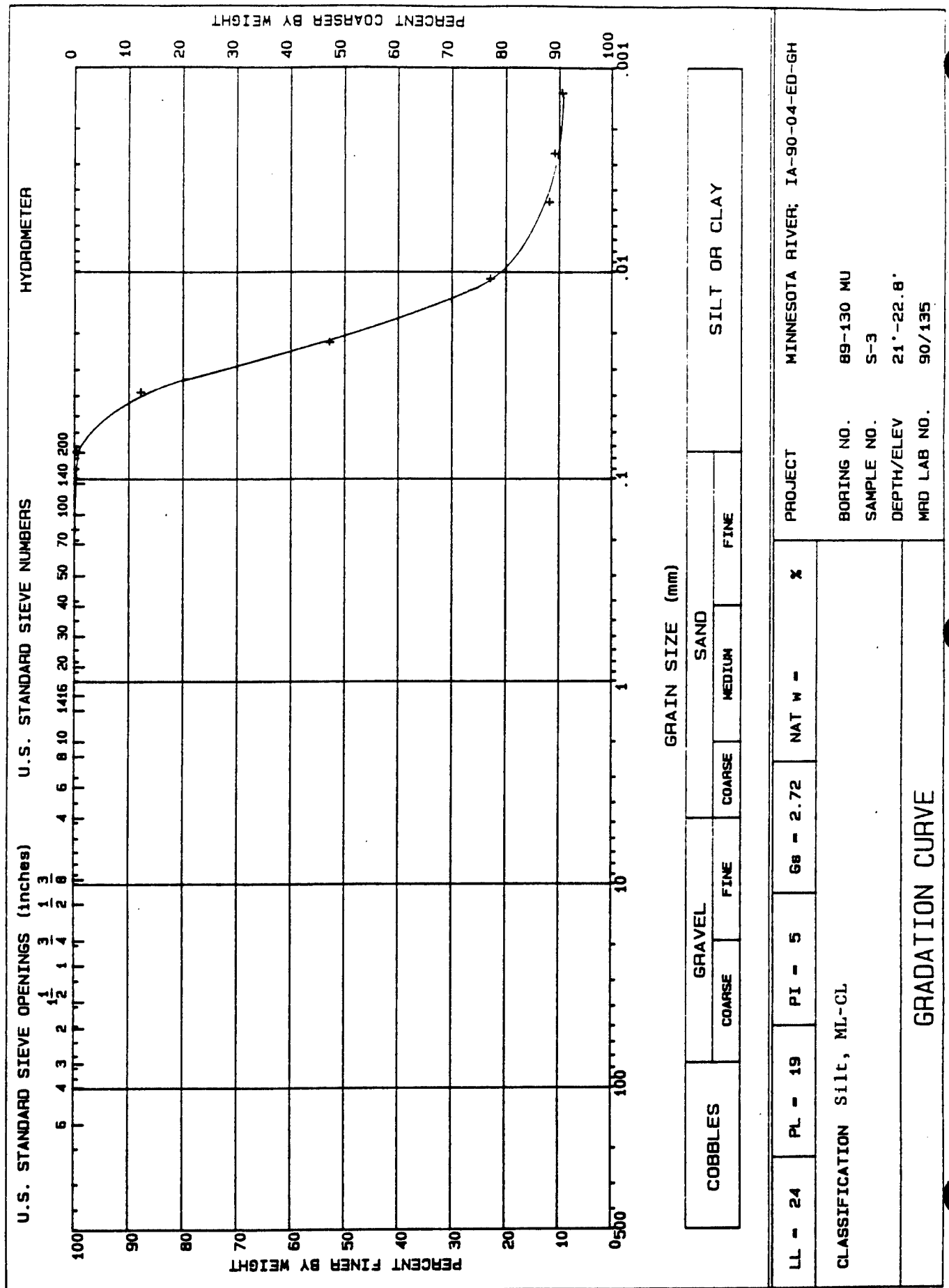
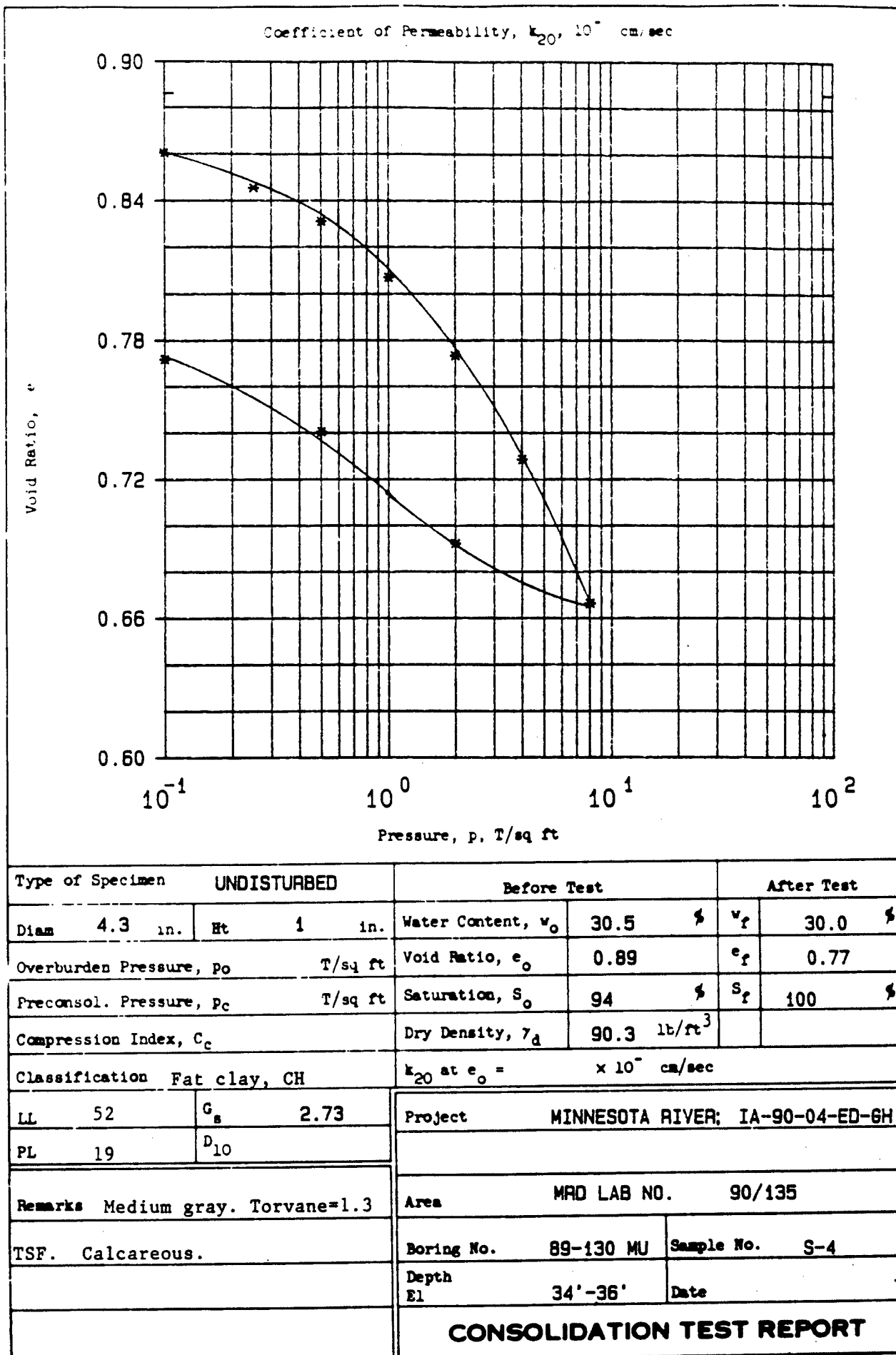


Figure C-524

FIGURE 8





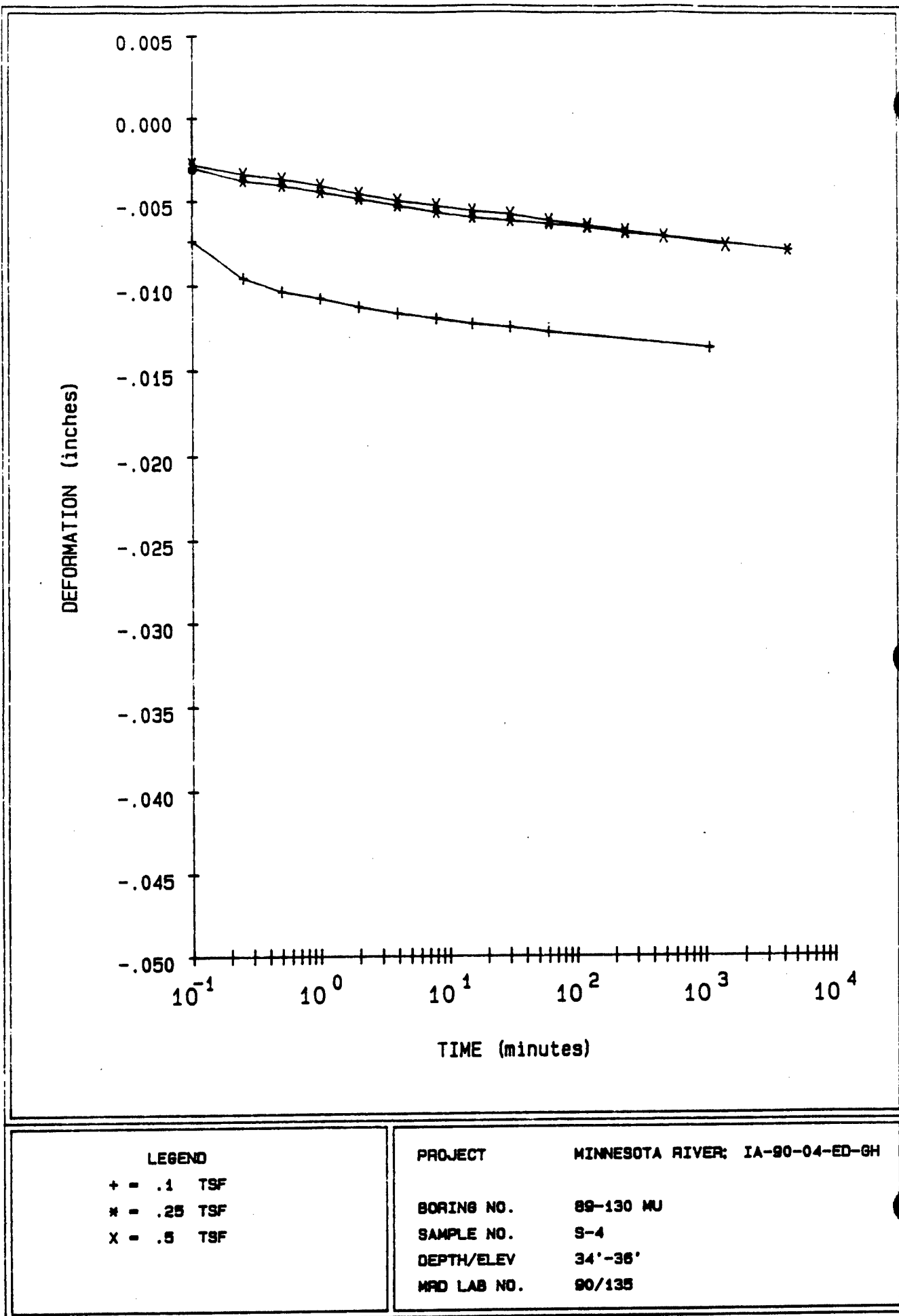
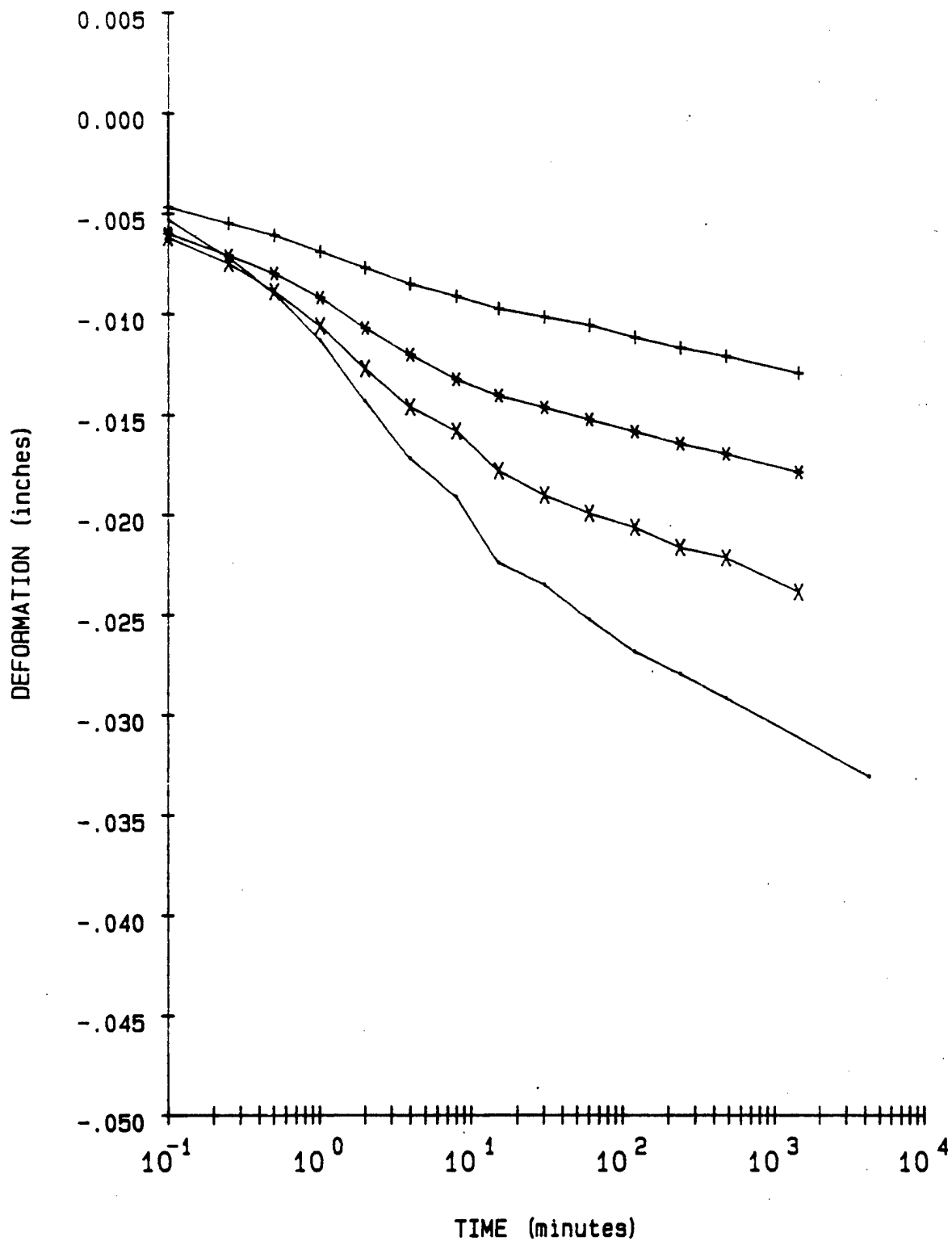


FIGURE 2  
Figure C-526



LEGEND

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-6H

BORING NO.

89-130 MU

SAMPLE NO.

S-4

DEPTH/ELEV

34'-38'

MRD LAB NO.

90/135

FIGURE 3

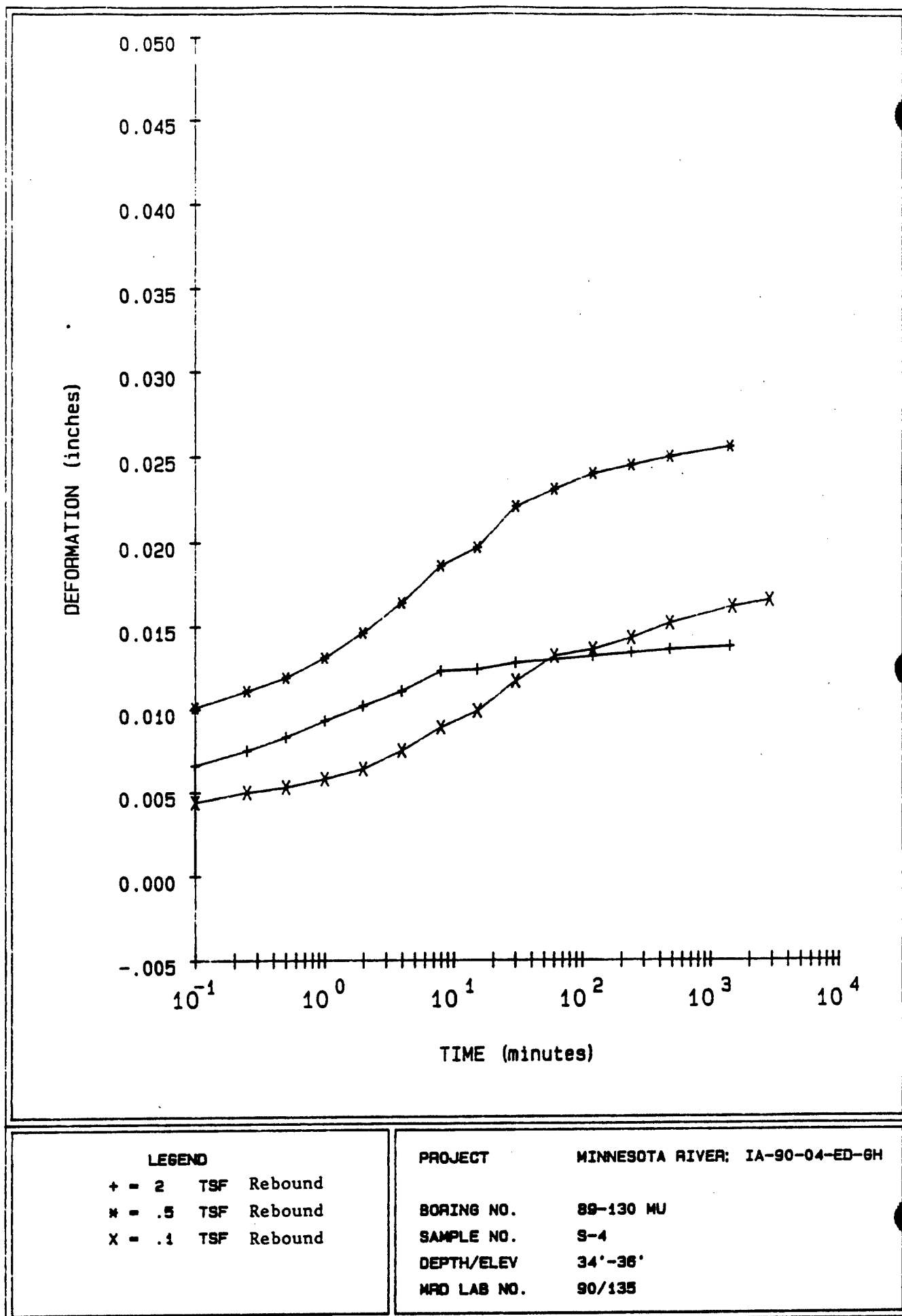


FIGURE 4

# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-130 MU

Sample No. S-4

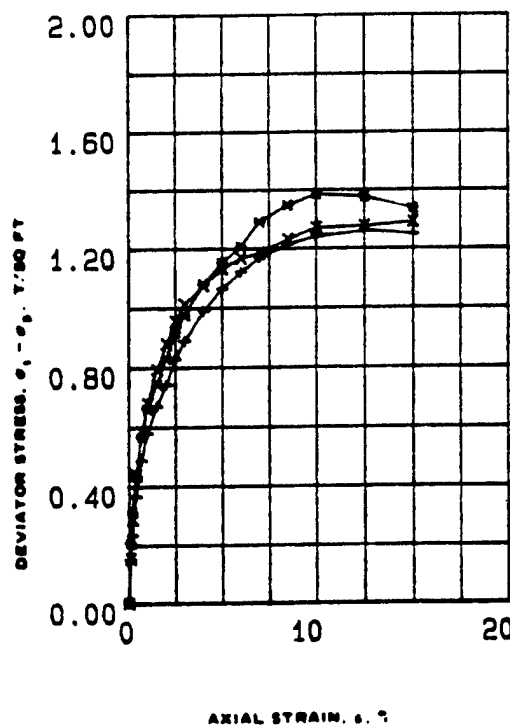
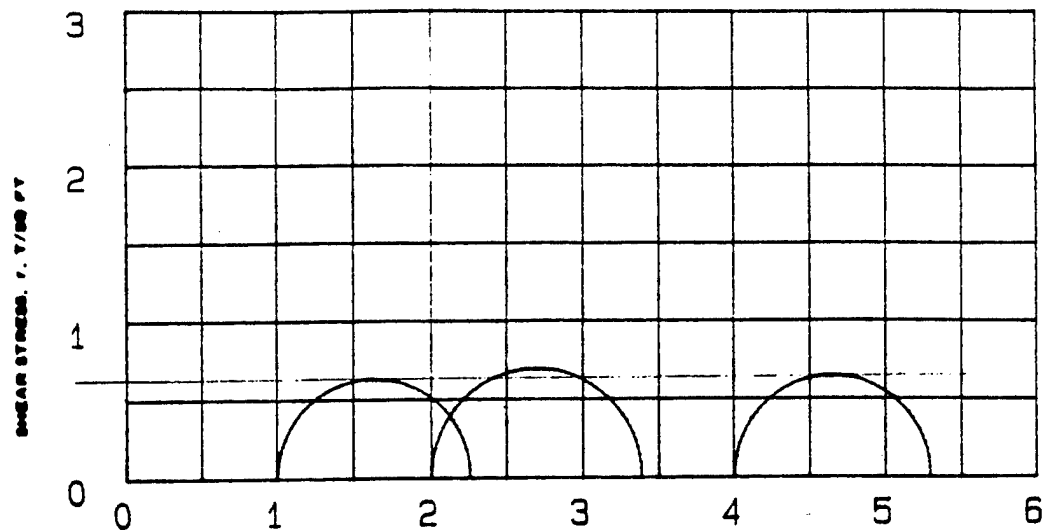
Depth/Elev 34'-36'

MRD Lab No. 90/135

$$\begin{aligned} G_s &= 2.73 \\ e_o &= 0.886 \\ 0.42e_o &= 0.372 \end{aligned}$$

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
30.5	342.1	90.3	0.886		94.1
30.0	342.1	91.6	0.860	0.10	95.2
30.0	342.1	92.3	0.845	0.25	96.9
30.0	342.1	93.0	0.831	0.50	98.6
30.0	342.1	94.3	0.807	1.00	100.0
30.0	342.1	96.1	0.773	2.00	100.0
30.0	342.1	98.6	0.728	4.00	100.0
30.0	342.1	102.2	0.666	8.00	100.0
30.0	342.1	100.7	0.692	2.00	100.0
30.0	342.1	97.9	0.740	0.50	100.0
30.0	342.1	96.1	0.772	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.867
2	0.848
3	0.829
4	0.811
5	0.792
6	0.773
7	0.754
8	0.735
9	0.716
10	0.697
11	0.679
12	0.660
13	0.641
14	0.622



NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (+)	3 (X)
INITIAL	WATER CONTENT, %	30.1	29.4	31.0
	DRY DENSITY LB/ CU FT	93.4	93.4	91.9
	SATURATION, %	100.0	97.0	99.0
	VOID RATIO	0.83	0.83	0.85
BEFORE SHEAR	WATER CONTENT, %	30.1	29.2	31.0
	DRY DENSITY LB/ CU FT	93.4	93.4	91.9
	SATURATION, %	100.0	97.0	99.0
	VOID RATIO	0.83	0.83	0.85
FINAL BACK PRESSURE, T/50 FT		0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		1.0	2.0	4.0
MAXIMUM DEVIATOR STRESS, T/50 FT		1.25	1.39	1.29
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$ , MIN		27.0	21.3	32.3
ULTIMATE DEVIATOR STRESS, T/50 FT		1.25	1.34	1.29
INITIAL DIAMETER, IN.		1.42	1.42	1.42
INITIAL HEIGHT, IN.		2.95	2.95	2.98

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS Fat clay, CH

LL 52 PL 19 PI 33 G<sub>s</sub> 2.73

REMARKS: Medium gray. Torvane=1.3TSF.

Calcareous.

TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST Q

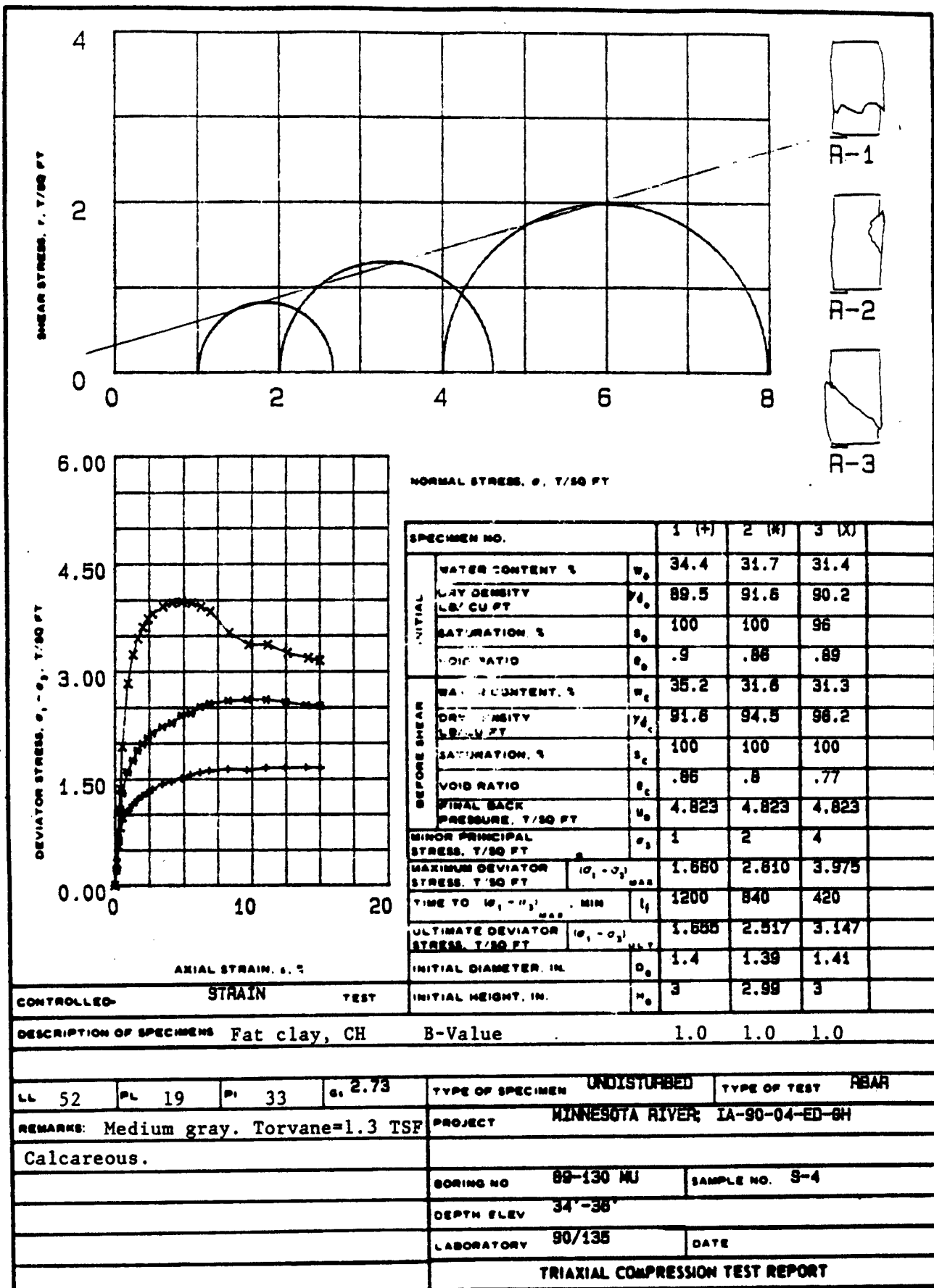
PROJECT MINNESOTA RIVER; IA-90-04-ED-6H

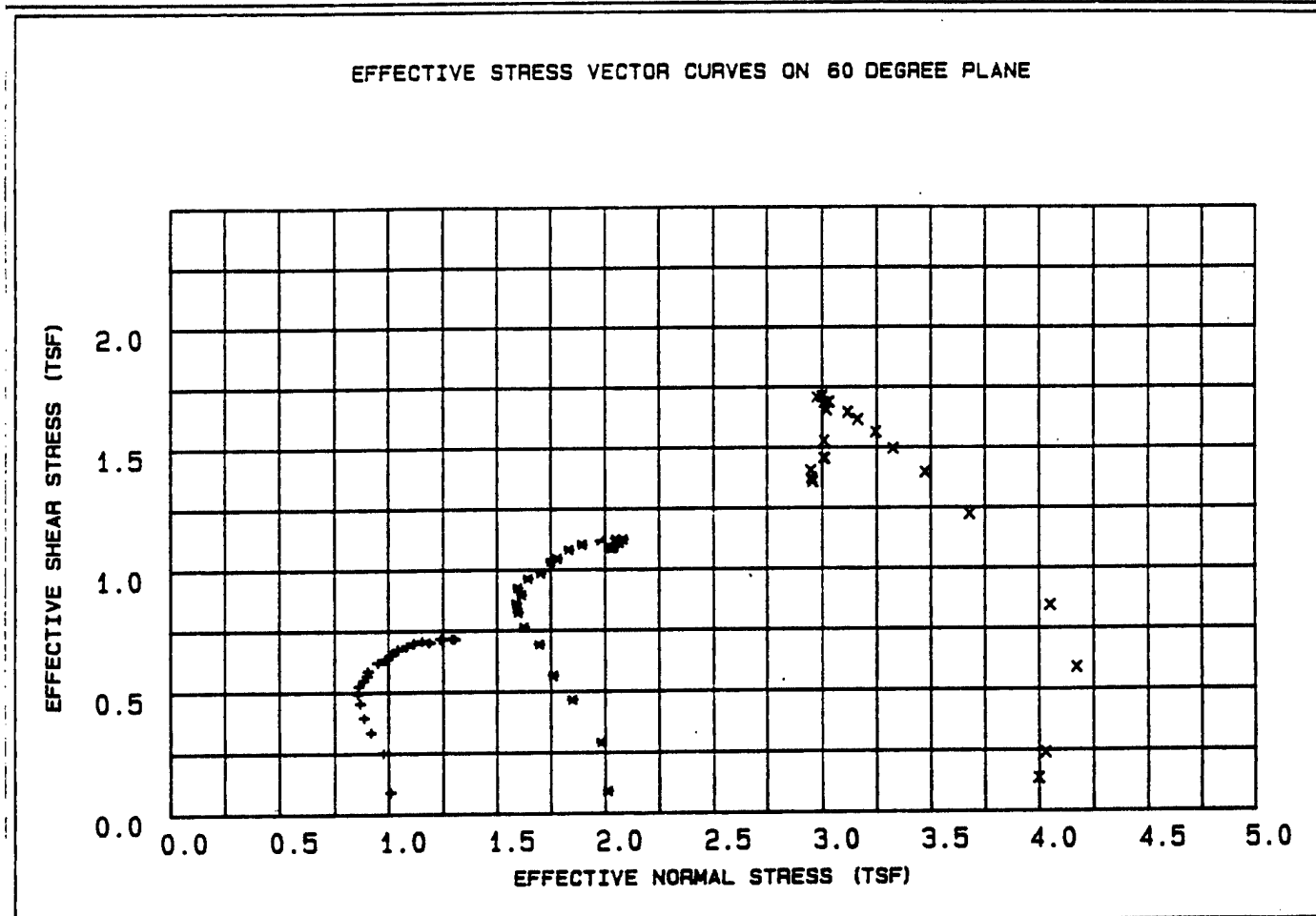
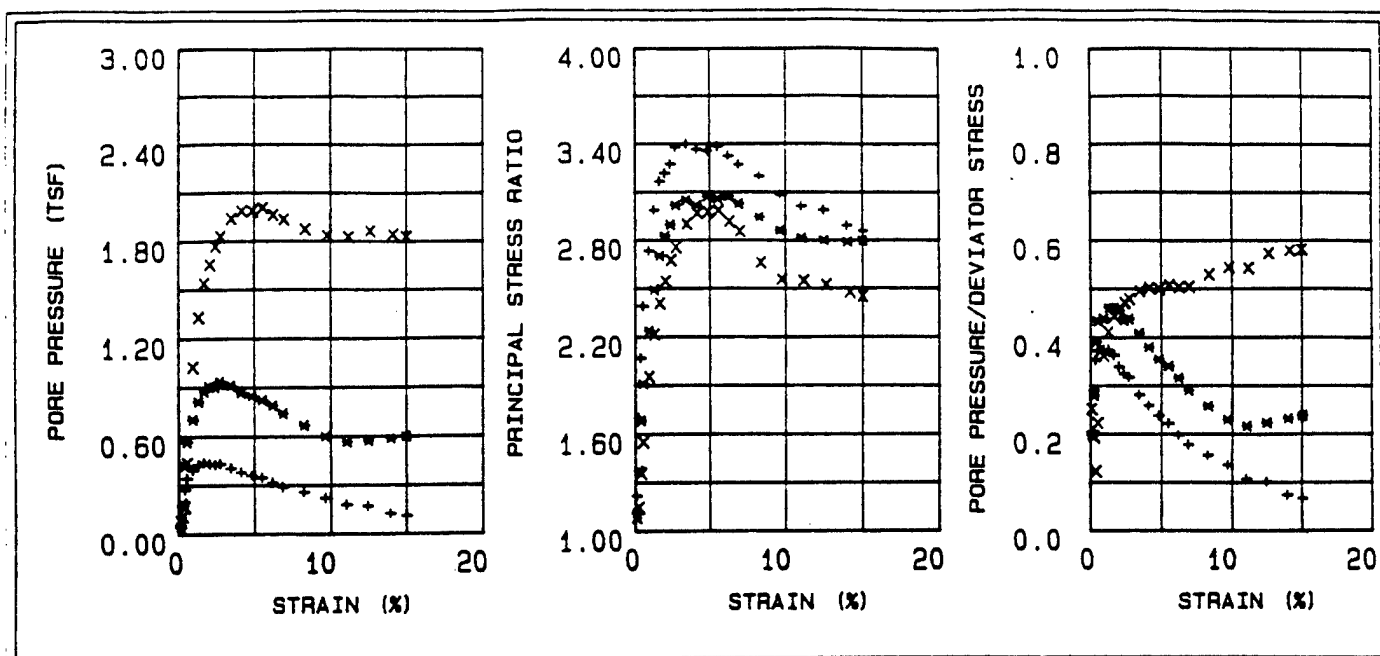
BORING NO 69-130 MU SAMPLE NO. 9-4

DEPTH ELEV 34'-36'

LABORATORY 90/135 DATE

TRIAXIAL COMPRESSION TEST REPORT





<p style="text-align: center;"><b>LEGEND</b></p> <p>+ = 1 TSF</p> <p>* = 2 TSF</p> <p>x = 4 TSF</p>	<p><b>PROJECT</b> MINNESOTA RIVER: IA-90-04-ED-6H</p> <p><b>BORING NO.</b> 89-130 MU</p> <p><b>SAMPLE NO.</b> S-4</p> <p><b>DEPTH/ELEV</b> 34'-36'</p> <p><b>MRO LAB NO.</b> 90/135</p>
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FIGURE 7  
Figure C-532



Table 1 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-4  
 Depth : 34'-36'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.206	0.042	1.215	0.204	1.009	0.089
30	0.26	0.580	0.169	1.698	0.291	0.975	0.250
45	0.41	0.775	0.274	2.067	0.354	0.918	0.334
60	0.55	0.915	0.341	2.388	0.373	0.886	0.395
90	0.94	1.050	0.393	2.730	0.374	0.867	0.453
120	1.29	1.141	0.426	2.985	0.374	0.856	0.492
150	1.65	1.212	0.440	3.165	0.363	0.860	0.523
180	2.01	1.266	0.429	3.216	0.339	0.885	0.547
210	2.37	1.311	0.424	3.274	0.324	0.901	0.566
240	2.71	1.356	0.430	3.377	0.317	0.906	0.585
300	3.43	1.434	0.402	3.398	0.281	0.953	0.619
360	4.10	1.469	0.378	3.364	0.258	0.986	0.634
420	4.80	1.512	0.358	3.355	0.237	1.016	0.653
480	5.49	1.562	0.345	3.384	0.221	1.042	0.674
540	6.17	1.595	0.313	3.322	0.197	1.082	0.688
600	6.86	1.618	0.286	3.268	0.177	1.115	0.698
720	8.23	1.639	0.254	3.196	0.155	1.152	0.707
840	9.62	1.625	0.218	3.078	0.135	1.184	0.701
960	11.01	1.658	0.175	3.010	0.106	1.236	0.716
1080	12.43	1.657	0.166	2.986	0.100	1.244	0.715
1200	13.94	1.660	0.121	2.888	0.073	1.290	0.717
1281	15.00	1.655	0.107	2.854	0.066	1.302	0.714

Table 2 - Triaxial  $\bar{R}$  Test Results

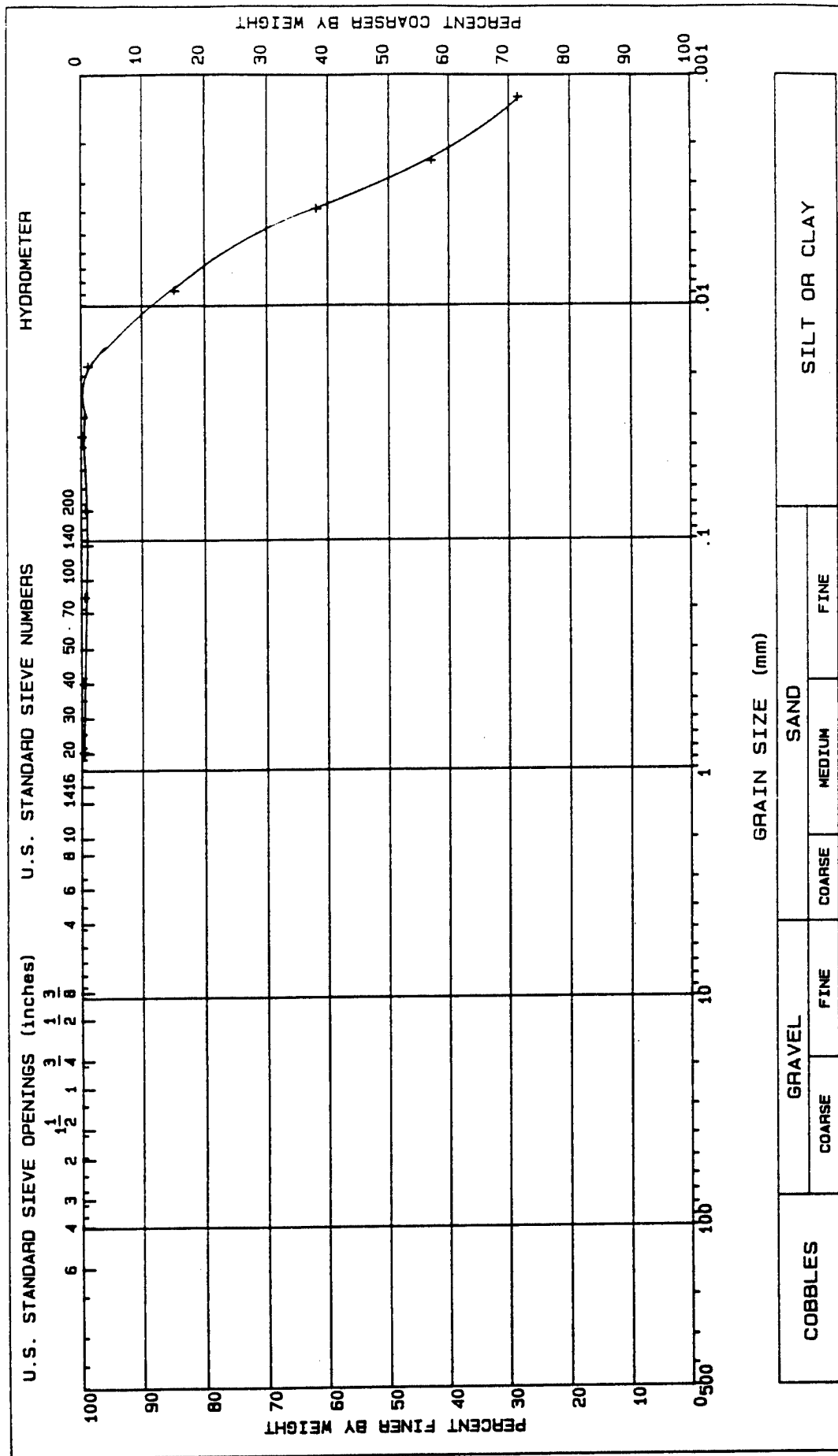
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-4  
 Depth : 34'-36'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.210	0.041	1.107	0.197	2.011	0.091
30	0.26	0.673	0.188	1.371	0.280	1.979	0.290
45	0.41	1.076	0.421	1.682	0.391	1.846	0.465
60	0.55	1.305	0.565	1.909	0.433	1.758	0.563
90	0.94	1.604	0.703	2.237	0.439	1.694	0.692
120	1.30	1.767	0.814	2.490	0.461	1.624	0.763
150	1.66	1.910	0.877	2.701	0.460	1.596	0.824
180	2.02	1.995	0.906	2.824	0.455	1.588	0.861
210	2.38	2.078	0.903	2.895	0.435	1.612	0.897
240	2.72	2.144	0.937	3.017	0.438	1.594	0.925
300	3.44	2.233	0.911	3.050	0.408	1.642	0.964
360	4.12	2.286	0.865	3.014	0.379	1.701	0.986
420	4.82	2.392	0.845	3.070	0.354	1.747	1.032
480	5.51	2.422	0.822	3.057	0.340	1.778	1.045
5	6.19	2.508	0.789	3.070	0.315	1.832	1.082
600	6.88	2.555	0.739	3.025	0.290	1.893	1.103
720	8.26	2.593	0.665	2.942	0.257	1.977	1.119
840	9.65	2.610	0.597	2.860	0.229	2.049	1.126
960	11.05	2.607	0.562	2.813	0.216	2.084	1.125
1080	12.47	2.568	0.571	2.797	0.223	2.065	1.109
1200	13.99	2.526	0.586	2.786	0.232	2.039	1.090
1277	15.00	2.517	0.597	2.794	0.238	2.026	1.087

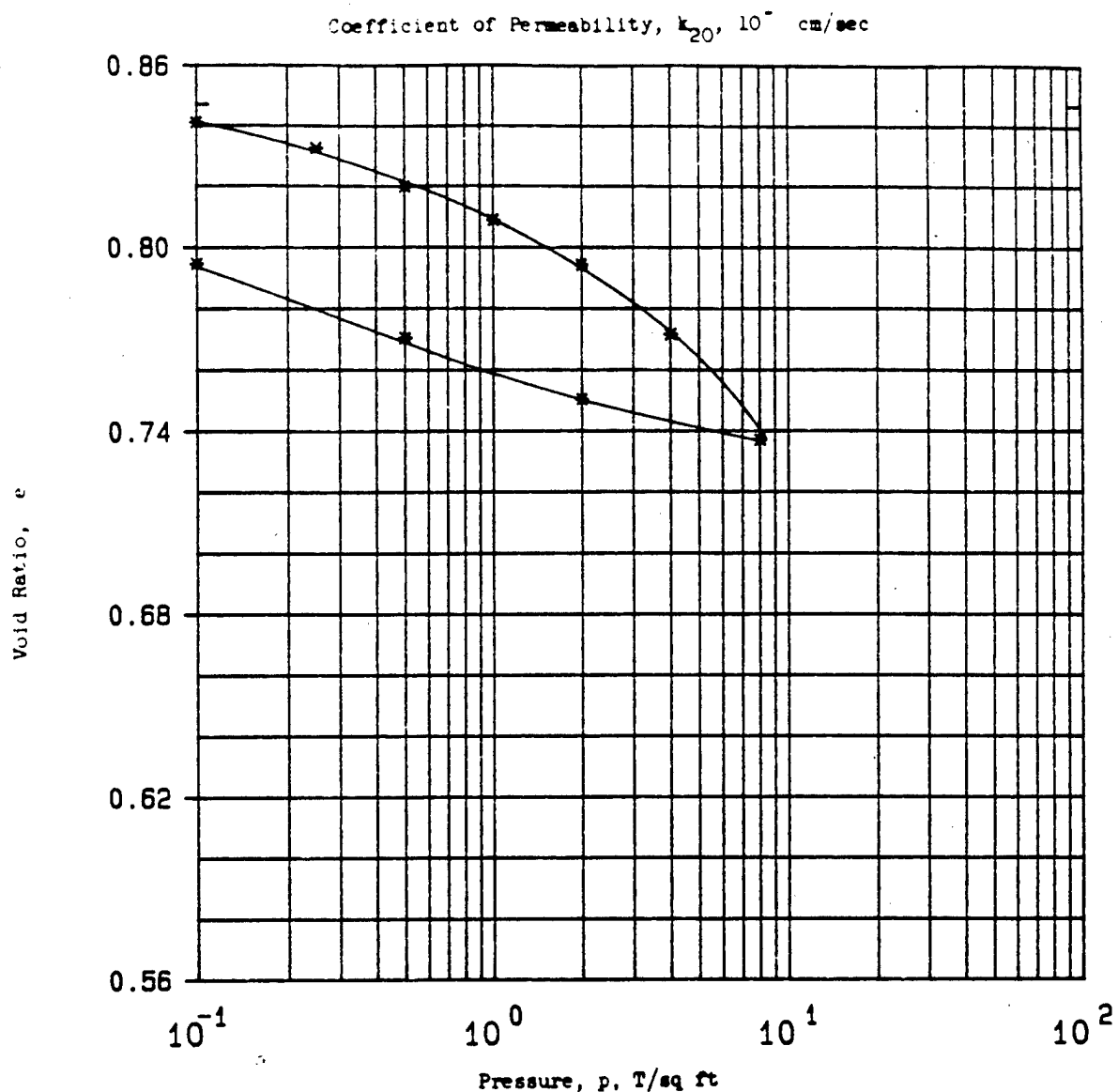
Table 3 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-4  
 Depth : 34'-36'  
 Confining Pressure : 4 TSF

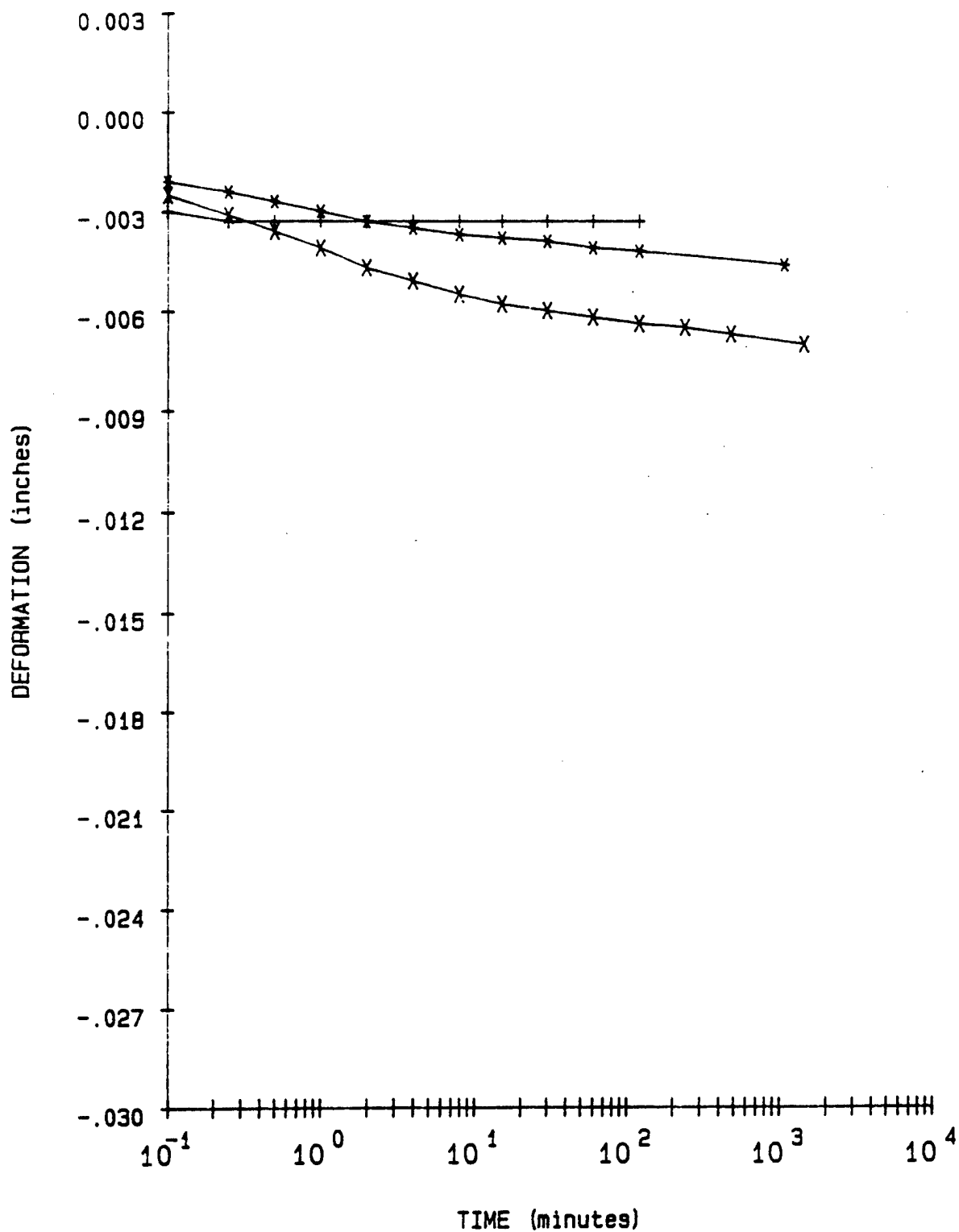
Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.12	0.313	0.079	1.080	0.252	3.998	0.135
30	0.27	0.557	0.108	1.143	0.194	4.030	0.240
45	0.41	1.362	0.166	1.355	0.122	4.171	0.588
60	0.56	1.955	0.435	1.548	0.223	4.049	0.844
90	0.95	2.834	1.024	1.952	0.362	3.678	1.223
120	1.31	3.237	1.330	2.213	0.411	3.471	1.397
150	1.68	3.464	1.537	2.407	0.444	3.321	1.495
180	2.04	3.620	1.653	2.543	0.457	3.243	1.563
210	2.41	3.741	1.765	2.674	0.472	3.161	1.615
240	2.75	3.810	1.828	2.754	0.480	3.115	1.645
300	3.48	3.911	1.939	2.898	0.496	3.029	1.688
360	4.16	3.961	1.985	2.966	0.502	2.996	1.709
420	4.87	<del>3.975</del>	<del>1.985</del>	2.973	0.500	2.999	1.715
480	5.57	3.955	2.006	2.983	0.508	2.973	1.707
	6.25	3.903	1.960	2.913	0.503	3.006	1.685
600	6.96	3.834	1.931	2.853	0.504	3.018	1.655
720	8.35	3.536	1.869	2.659	0.529	3.007	1.526
840	9.76	3.372	1.832	2.555	0.544	3.003	1.455
960	11.17	3.368	1.823	2.547	0.542	3.011	1.454
1080	12.61	3.252	1.861	2.520	0.573	2.944	1.404
1200	14.14	3.179	1.840	2.472	0.579	2.947	1.372
1265	15.00	3.147	1.826	2.448	0.581	2.952	1.358



LL - 52	PL - 19	PI - 33	Gs - 2.73	NAT W -	%	PROJECT	MINNESOTA PIVER: IA-90-04-ED-GH
CLASSIFICATION Fat clay, CH						BORING NO.	89-130 MU
						SAMPLE NO.	S-4
						DEPTH/ELEV	34'-36'
						MRD LAB NO.	90/135
GRADATION CURVE							



Type of Specimen		UNDISTURBED		Before Test		After Test	
Diam	4.4 in.	Ht	1 in.	Water Content, $w_o$	30.2 %	$w_f$	30.2 %
Overburden Pressure, $p_o$		T/sq ft		Void Ratio, $e_o$	0.85	$e_f$	0.79
Preconsol. Pressure, $p_c$		T/sq ft		Saturation, $S_o$	97 %	$S_f$	100 %
Compression Index, $C_c$				Dry Density, $\gamma_d$	91.9 lb/ft <sup>3</sup>		
Classification		Fat clay, CH		$k_{20}$ at $e_o$ = $\times 10^{-7}$ cm/sec			
LL	52	$G_s$	2.72	Project			
PL	20	$D_{10}$		MINNESOTA RIVER; IA-90-04-ED-GH			
Remarks				Area			
Medium gray. Torvane=1.6				MRD LAB NO. 90/135			
TSF. Calcareous.				Boring No.		Sample No.	
				89-130 MU		S-5	
				Depth		Date	
				El		42'-44'	
<b>CONSOLIDATION TEST REPORT</b>							



LEGEND

+ = .1 TSF  
 \* = .25 TSF  
 x = .5 TSF

PROJECT

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-5

DEPTH/ELEV

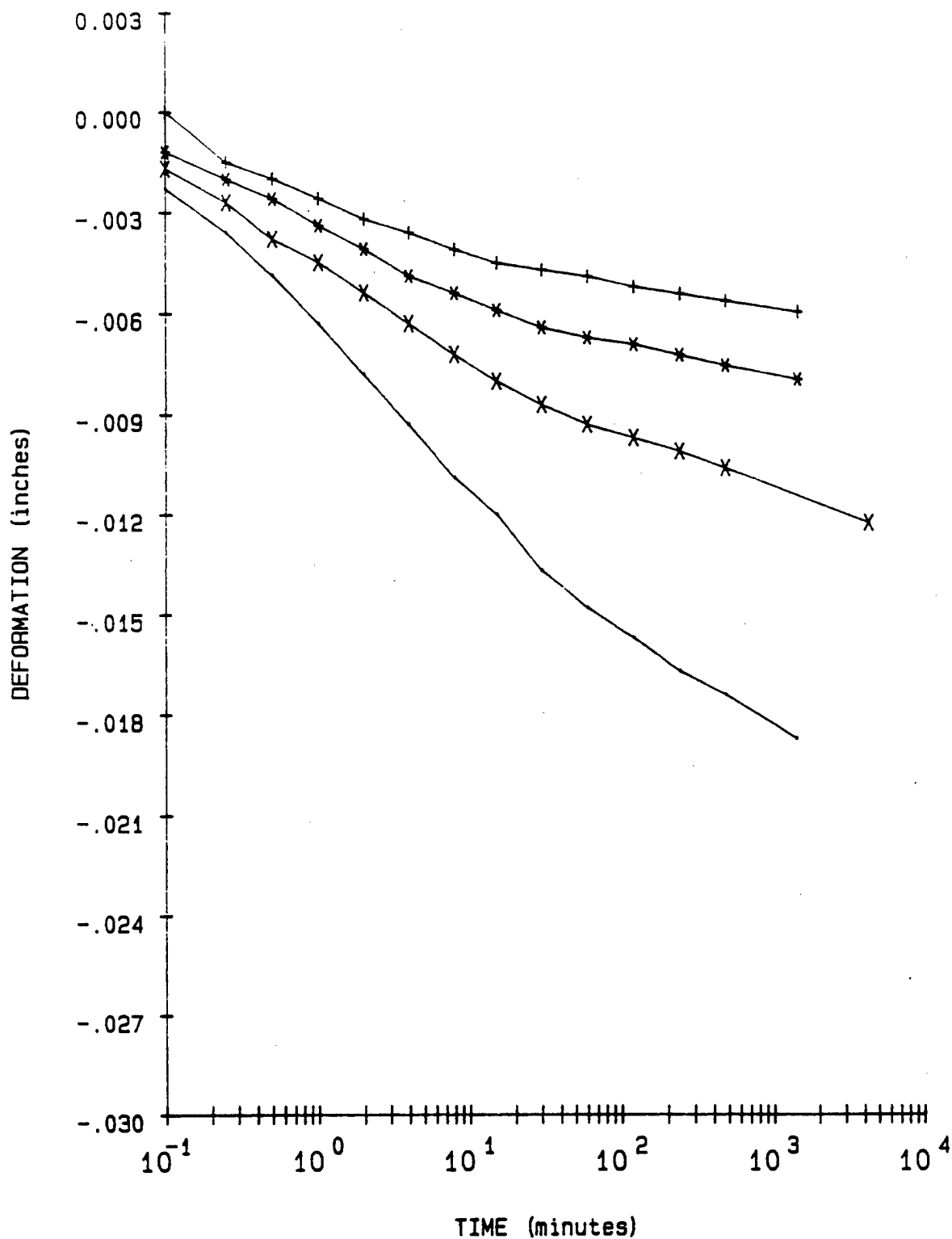
42'-44'

MRD LAB NO.

90/135

FIGURE 10

Figure C-538



**LEGEND**

+ = 1 TSF  
 \* = 2 TSF  
 x = 4 TSF  
 - = 8 TSF

**PROJECT**

MINNESOTA RIVER: IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-5

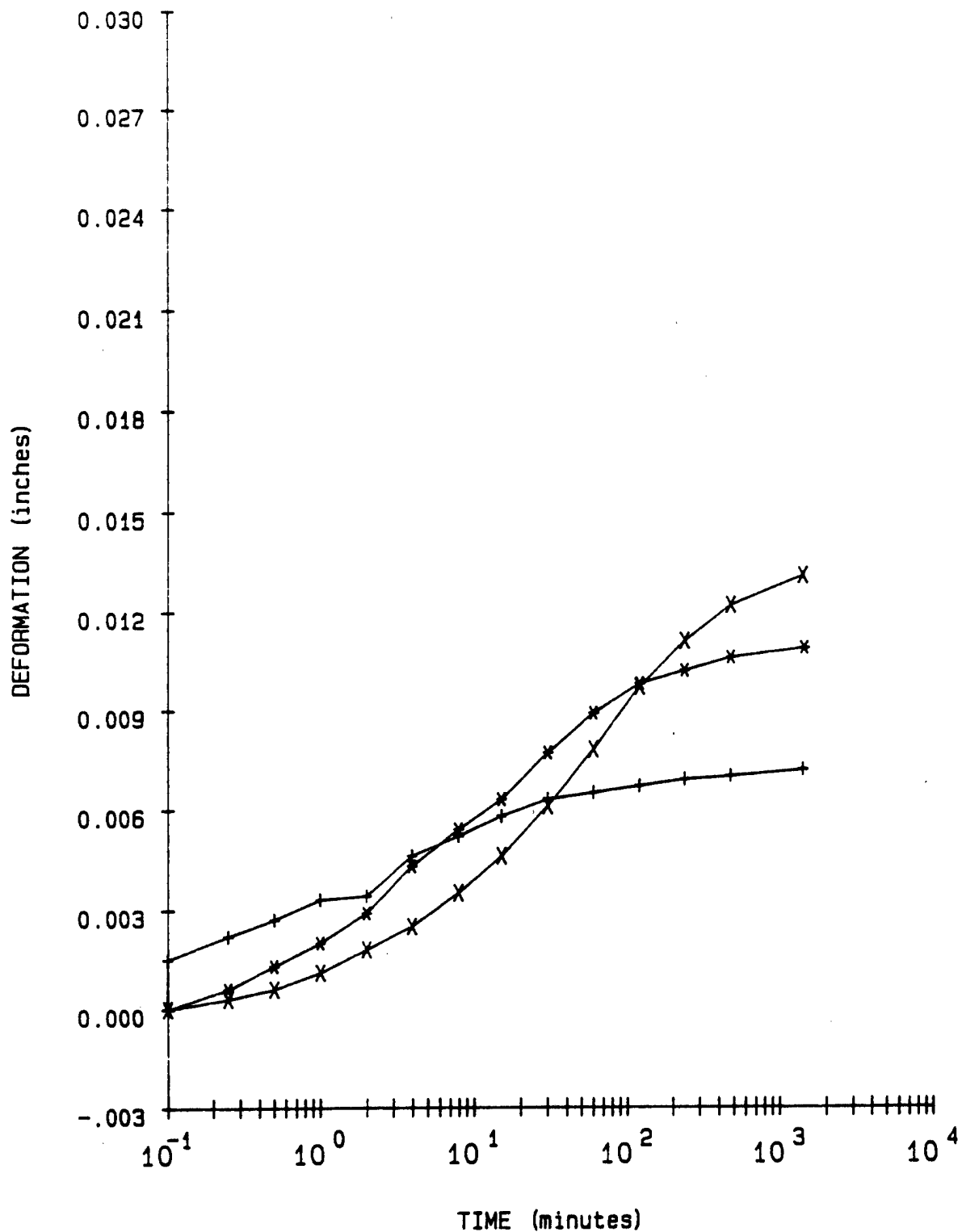
DEPTH/ELEV

42'-44'

MRD LAB NO.

90/135

**FIGURE 11**



**LEGEND**

+ = 2 TSF Rebound  
 \* = .5 TSF Rebound  
 x = .1 TSF Rebound

**PROJECT**

MINNESOTA RIVER; IA-90-04-ED-6H

**BORING NO.**

89-130 MU

**SAMPLE NO.**

S-5

**DEPTH/ELEV**

42'-44'

**MRD LAB NO.**

90/135

**FIGURE 12**

Figure C-540



# Consolidation Test Data

Project MINNESOTA RIVER; IA-90-04-ED-GH

Boring No. 89-130 MU

Sample No. S-5

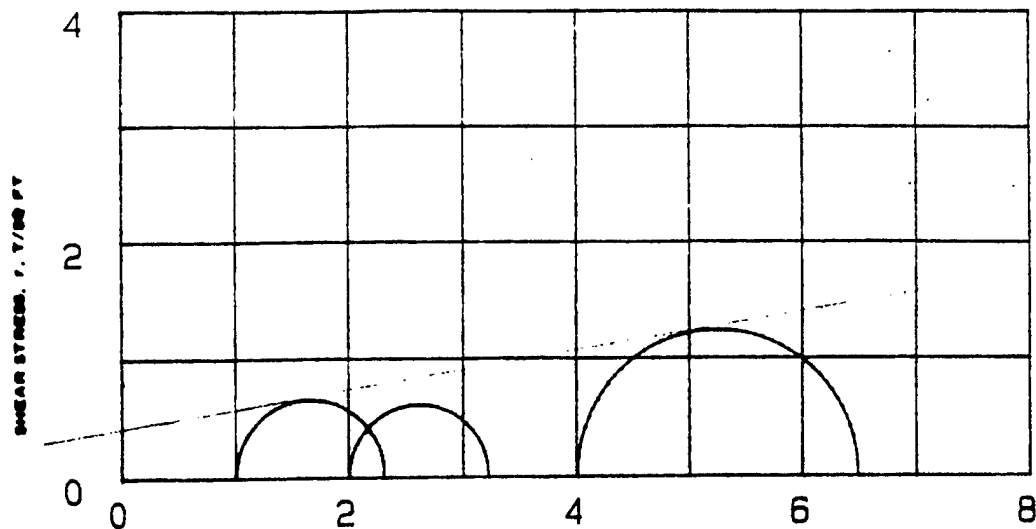
Depth/Elev 42'-44'

MRD Lab No. 90/135

Gs = 2.72  
eo = 0.847  
0.42eo = 0.356

Water Content (%)	Dry Weight (gms)	Dry Density (PCF)	Void Ratio	Pressure (TSF)	Saturation (%)
30.2	373.3	91.9	0.847		96.9
30.2	373.3	92.2	0.841	0.10	97.7
30.2	373.3	92.6	0.833	0.25	98.7
30.2	373.3	93.3	0.820	0.50	100.0
30.2	373.3	93.8	0.809	1.00	100.0
30.2	373.3	94.6	0.794	2.00	100.0
30.2	373.3	95.8	0.772	4.00	100.0
30.2	373.3	97.7	0.737	8.00	100.0
0.2	373.3	97.0	0.750	2.00	100.0
30.2	373.3	95.9	0.770	0.50	100.0
30.2	373.3	94.6	0.795	0.10	100.0

Axial Strain (%)	Void Ratio
1	0.829
2	0.810
3	0.792
4	0.773
5	0.755
6	0.736
7	0.718
8	0.699



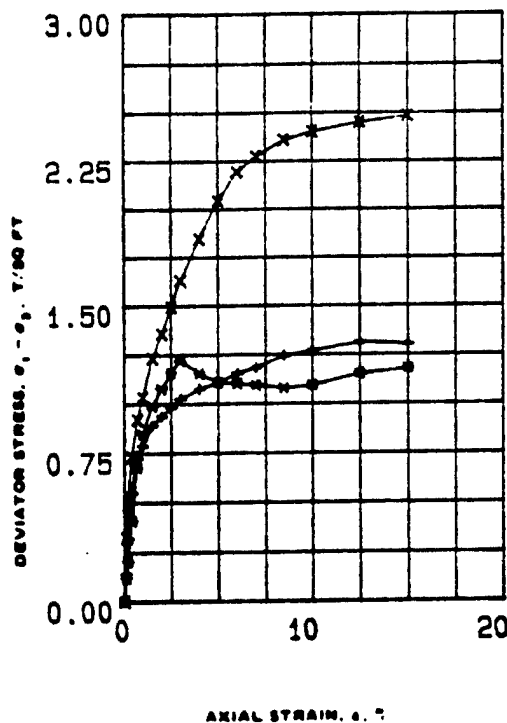
Q-1



Q-2



Q-3



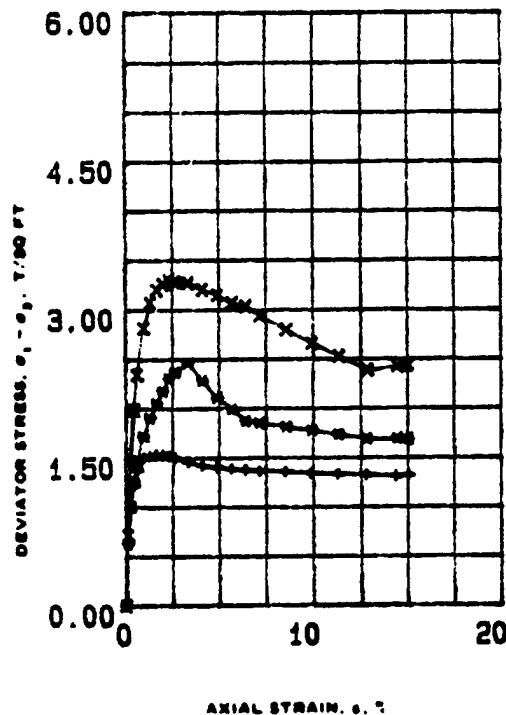
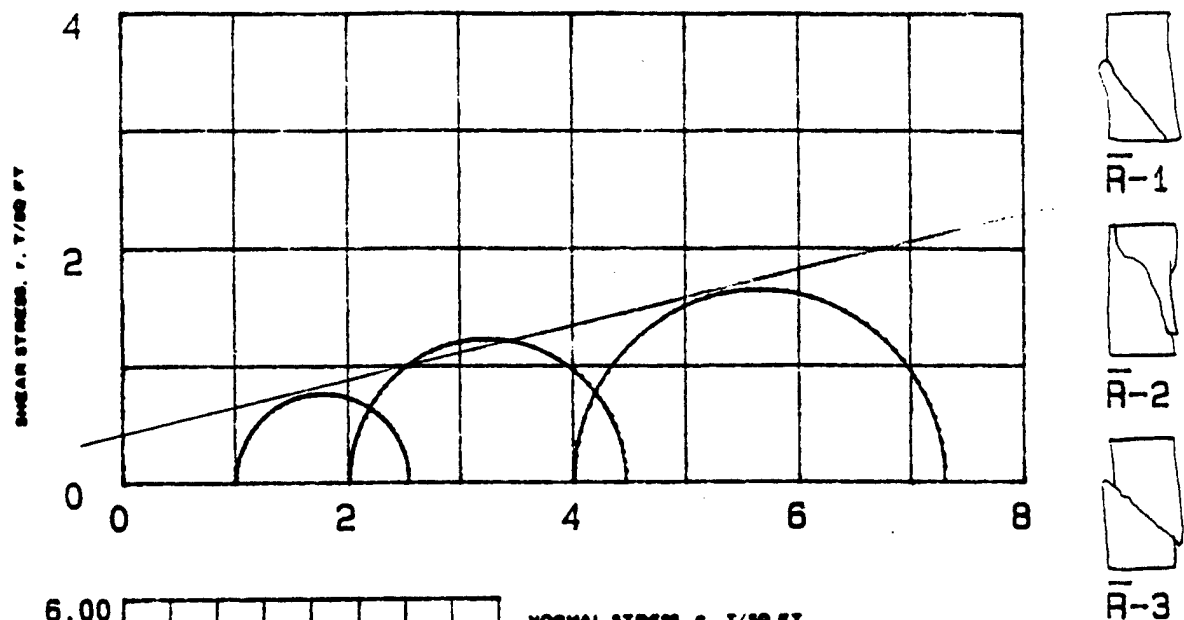
NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (+)	3 (X)
INITIAL	WATER CONTENT, %	$w_o$ 30.8	29.5	28.2
	WET DENSITY LB/ CU FT	$\gamma_o$ 92.5	92.5	92.4
	SATURATION, %	$s_o$ 100.0	96.0	98.0
	VOID RATIO	$e_o$ 0.84	0.84	0.78
BEFORE SHEAR	WATER CONTENT, %	$w_c$ 30.7	29.5	28.2
	WET DENSITY LB/ CU FT	$\gamma_c$ 92.5	92.7	98.3
	SATURATION, %	$s_c$ 100.0	96.0	100.0
	VOID RATIO	$e_c$ 0.84	0.83	0.76
FINAL BACK PRESSURE, T/50 FT		$u_o$ 0.0	0.0	0.0
MINOR PRINCIPAL STRESS, T/50 FT		$\sigma_3$ 1.0	2.0	4.0
MAXIMUM DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{max}$ 1.31	1.22	2.48
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		$t_1$ 26.8	7.3	33.0
ULTIMATE DEVIATOR STRESS, T/50 FT		$(\sigma_1 - \sigma_3)_{ult}$ 1.30	1.18	2.48
INITIAL DIAMETER, IN.		$D_o$ 1.42	1.43	1.43
INITIAL HEIGHT, IN.		$H_o$ 2.99	2.99	2.99

CONTROLLED-STRAIN TEST

DESCRIPTION OF SPECIMENS Fat clay, CH

LL 52	PL 20	PI 32	G <sub>s</sub> 2.72	TYPE OF SPECIMEN	UNDISTURBED	TYPE OF TEST	Q	
REMARKS: Medium gray. Trovane=1.6 TSF.				PROJECT				MINNESOTA RIVER; IA-90-04-ED-8H
Calcareous.								
				BORING NO.	89-130 MU	SAMPLE NO.	S-5	
				DEPTH ELEV	42'-44'			
				LABORATORY	90/135	DATE		
TRIAXIAL COMPRESSION TEST REPORT								



NORMAL STRESS,  $\sigma$ , T/50 FT

SPECIMEN NO.		1 (+)	2 (H)	3 (X)
INITIAL	WATER CONTENT, %	29.7	30.4	30.8
	DRY DENSITY LB/CU FT	93.8	93.3	91.8
	SATURATION, %	100	100	98
	VOID RATIO	.81	.82	.85
BEFORE SHEAR	WATER CONTENT, %	31.8	32.2	32.2
	DRY DENSITY LB/CU FT	84.7	86.2	86.3
	SATURATION, %	100	100	100
	VOID RATIO	.79	.78	.78
FINAL BACK PRESSURE, T/50 FT		5.543	5.543	5.543
MINOR PRINCIPAL STRESS, T/50 FT		1	2	4
MAXIMUM DEVIATOR STRESS, T/50 FT		1.532	2.461	3.286
TIME TO $(\sigma_1 - \sigma_3)_{max}$ , MIN		180	300	210
ULTIMATE DEVIATOR STRESS, T/50 FT		1.318	1.677	2.427
INITIAL DIAMETER, IN.		1.39	1.39	1.39
INITIAL HEIGHT, IN.		2.99	2.99	2.99

CONTROLLED- STRAIN TEST

DESCRIPTION OF SPECIMENS Fat clay, CH B-Value 1.0 1.0 1.0

LL 52 PL 20  $P_i$  32  $G_s$  2.72

TYPE OF SPECIMEN UNDISTURBED TYPE OF TEST HBAR

REMARKS: Medium gray. Torvane=1.6TSF.

PROJECT MINNESOTA RIVER IA-80-04-ED-8H

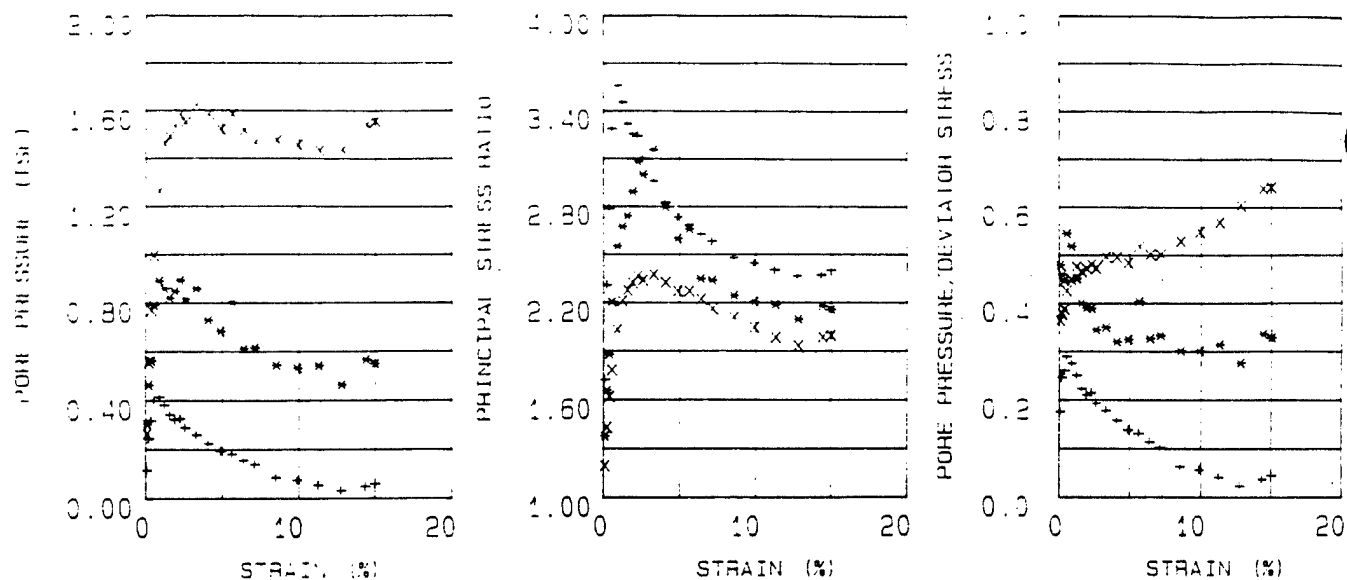
Calcareous.

BORING NO. 88-130 MJ SAMPLE NO. 8-8

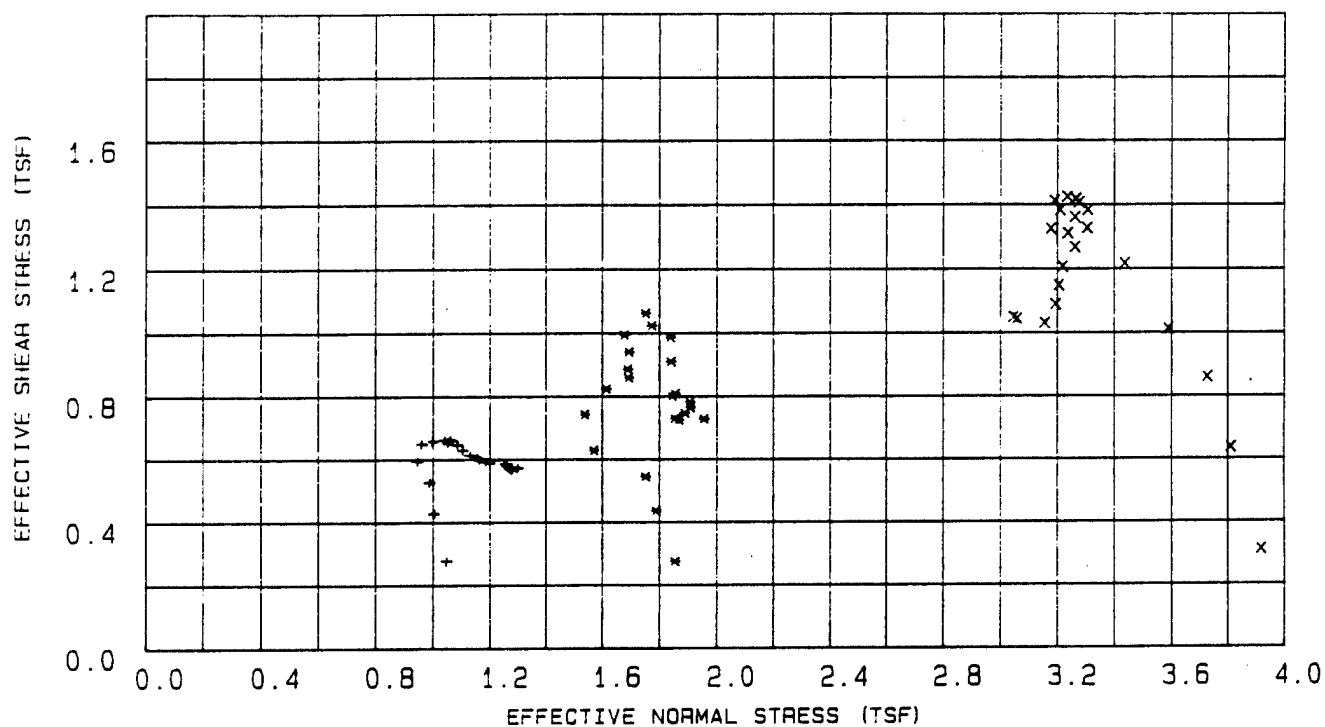
DEPTH ELEV 42'-44'

LABORATORY 80/135 DATE

TRIAXIAL COMPRESSION TEST REPORT



EFFECTIVE STRESS VECTOR CURVES ON 60 DEGREE PLANE



LEGEND

- + = 1 TSF
- \* = 2 TSF
- x = 4 TSF

PROJECT

MINNESOTA RIVER; IA-90-04-ED-GH

BORING NO.

89-130 MU

SAMPLE NO.

S-5

DEPTH/ELEV

42'-44'

MRD LAB NO.

90/135

FIGURE 15

Table 4 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-5  
 Depth : 42'-44'  
 Confining Pressure : 1 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.640	0.112	1.721	0.175	1.047	0.276
30	0.24	0.989	0.243	2.306	0.246	1.002	0.427
45	0.41	1.219	0.316	2.783	0.260	0.986	0.526
60	0.58	1.377	0.397	3.285	0.289	0.944	0.594
90	0.92	1.503	0.412	3.558	0.275	0.960	0.649
120	1.25	1.522	0.379	3.451	0.250	0.998	0.657
150	1.59	1.531	0.339	3.316	0.222	1.040	0.661
180	1.93	1.532	0.320	3.251	0.209	1.059	0.661
210	2.26	1.515	0.324	3.240	0.214	1.051	0.654
240	2.60	1.498	0.287	3.099	0.192	1.084	0.646
300	3.30	1.454	0.257	2.957	0.177	1.103	0.628
400	4.07	1.418	0.222	2.822	0.157	1.129	0.612
480	4.86	1.399	0.191	2.729	0.137	1.155	0.604
540	5.61	1.381	0.179	2.682	0.130	1.163	0.596
600	6.36	1.372	0.154	2.623	0.113	1.186	0.592
720	7.10	1.362	0.137	2.579	0.101	1.200	0.588
840	8.50	1.354	0.083	2.476	0.062	1.252	0.584
960	9.85	1.337	0.072	2.442	0.055	1.259	0.577
1080	11.25	1.327	0.052	2.400	0.040	1.277	0.573
1200	12.74	1.322	0.029	2.361	0.022	1.298	0.571
1200	14.33	1.306	0.046	2.369	0.036	1.277	0.564
1250	15.00	1.318	0.057	2.398	0.044	1.269	0.569

Table 5 - Triaxial  $\bar{R}$  Test Results

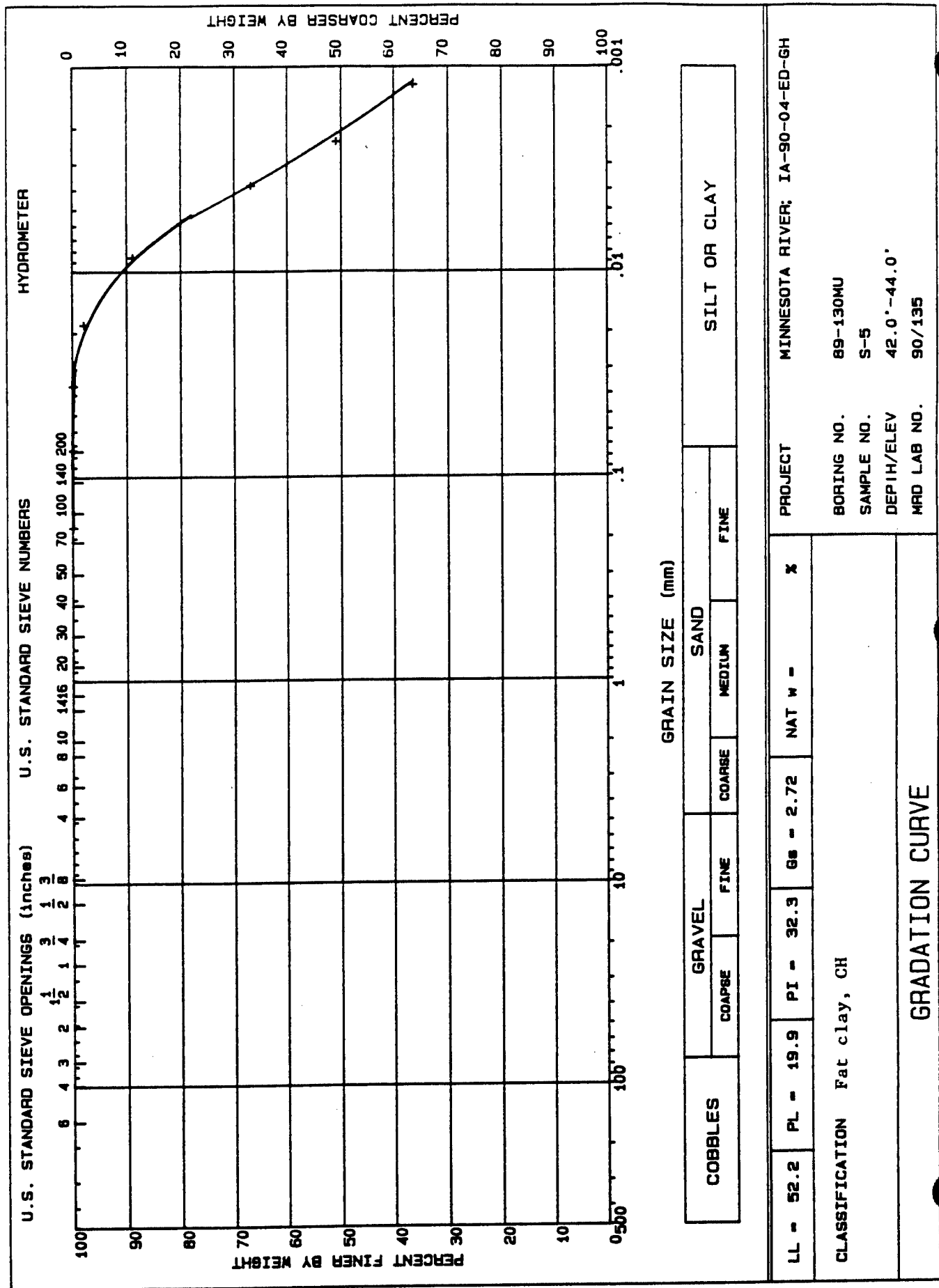
Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-5  
 Depth : 42'-44'  
 Confining Pressure : 2 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.635	0.304	1.374	0.479	1.853	0.274
30	0.24	1.008	0.462	1.656	0.459	1.788	0.435
45	0.41	1.261	0.561	1.877	0.446	1.751	0.544
60	0.58	1.454	0.791	2.203	0.544	1.569	0.628
90	0.92	1.721	0.890	2.550	0.517	1.536	0.743
120	1.26	1.907	0.858	2.670	0.450	1.614	0.823
150	1.60	2.054	0.819	2.739	0.399	1.689	0.886
180	1.94	2.179	0.847	2.890	0.389	1.693	0.941
210	2.28	2.304	0.893	3.081	0.388	1.677	0.994
240	2.62	2.370	0.814	2.998	0.344	1.773	1.023
300	3.32	2.461	0.858	3.155	0.349	1.751	1.062
360	4.09	2.282	0.727	2.793	0.319	1.838	0.985
420	4.89	2.105	0.681	2.596	0.324	1.840	0.909
480	5.64	1.988	0.800	2.656	0.403	1.692	0.858
540	6.39	1.872	0.609	2.346	0.326	1.855	0.808
600	7.14	1.850	0.614	2.335	0.332	1.844	0.799
720	8.55	1.809	0.542	2.240	0.300	1.906	0.781
840	9.91	1.769	0.530	2.203	0.300	1.908	0.763
960	11.31	1.728	0.540	2.184	0.313	1.888	0.746
1080	12.81	1.684	0.462	2.095	0.275	1.955	0.727
1200	14.41	1.688	0.565	2.176	0.335	1.853	0.729
1244	15.00	1.677	0.548	2.155	0.327	1.867	0.724

Table 6 - Triaxial  $\bar{R}$  Test Results

Project : MINNESOTA RIVER; IA-90-04-ED-GH  
 Boring Number : 89-130 MU  
 Sample Number : S-5  
 Depth : 42'-44'  
 Confining Pressure : 4 TSF

Time (min)	Strain (%)	Deviator Stress (TSF)	Induced Pore Pressure (TSF)	Principal Eff. Stress Ratio	Pore / Deviator A	Normal Stress (TSF)	Shear Stress (TSF)
15	0.10	0.715	0.260	1.191	0.364	3.917	0.309
30	0.24	1.471	0.554	1.427	0.377	3.810	0.635
45	0.41	1.989	0.768	1.616	0.387	3.725	0.859
60	0.58	2.344	0.994	1.780	0.425	3.586	1.012
90	0.92	2.817	1.262	2.029	0.448	3.435	1.216
120	1.26	3.072	1.458	2.209	0.475	3.303	1.326
150	1.60	3.201	1.488	2.274	0.465	3.305	1.382
180	1.94	3.258	1.533	2.321	0.471	3.274	1.406
210	2.28	3.296	1.582	2.363	0.480	3.234	1.423
240	2.62	3.281	1.548	2.338	0.472	3.264	1.416
300	3.32	3.268	1.620	2.373	0.496	3.189	1.411
360	4.10	3.200	1.582	2.323	0.495	3.210	1.381
420	4.90	3.148	1.518	2.268	0.483	3.261	1.359
480	5.65	3.065	1.582	2.268	0.517	3.177	1.323
540	6.41	3.033	1.514	2.220	0.500	3.237	1.309
600	7.16	2.934	1.465	2.158	0.500	3.261	1.266
720	8.56	2.793	1.473	2.105	0.528	3.218	1.205
840	9.92	2.656	1.454	2.043	0.548	3.204	1.147
960	11.33	2.521	1.431	1.981	0.568	3.193	1.088
1080	12.83	2.384	1.435	1.929	0.603	3.155	1.029
1200	14.43	2.417	1.541	1.983	0.638	3.057	1.043
1242	15.00	2.427	1.555	1.993	0.641	3.045	1.048





APPENDIX D

STRUCTURAL

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX D

STRUCTURAL

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MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX D

STRUCTURAL

PURPOSE

1. This appendix describes the methods used in the analysis and design of the structures for the Chaska Creek Flood Control Project, Chaska, Minnesota. It summarizes references, design criteria, materials and loads for the structure. The design of the major features are described individually.

2. Structural design computations are done to a level of detail to provide accurate quantities for the cost estimate and to assure stability, but not to develop details except for structures where such details are critical. Project features are sufficiently detailed to allow for preparation of the plans and specifications.

DESIGN CRITERIA

REINFORCED CONCRETE STRUCTURES

3. Specified Compressive Strength of Concrete:  $f'_c = 4000$  psi
4. Steel reinforcing bars: Grade 60
5. Minimum reinforcement cover - cast-in-place Hydraulic Structures:  
Any surface - 2 inches  
Concrete surfaces cast against earth or in contact with storm drainage water - 3 inches
6. Reinforcement details are not provided but will be developed in the Plans and Specifications

MATERIAL PROPERTIES

7. Structural grade steel: ASTM A36
8. Aluminum: 6061-T6
9. Steel Sheet Piling: ASTM A328
10. Unit weights: pcf

Concrete - 150  
Water - 62.5

# 11. Soil Unit Weights: pcf

	<u>moist</u>	<u>saturated</u>	<u>submerged</u>
Flotation	115	120	57.5
Lateral Pressure	120	125	62.5
Pervious Backfill for Structures Outside Levee	120	125	62.5

# 12. Soil Properties

	<u>phi</u> <u>(degrees)</u>	<u>c</u> <u>(psf)</u>
a. Pervious Backfill for Structures Outside Levee	30	0

# b. Outlet B - Native Soil in Levee

<u>Elevation</u>	<u>Term</u>	<u>phi</u>	<u>c</u>
Top of levee to 710	Short	0	1200
"	Long	27	0
710 to 680	Long	31	0

# c. Outlet C and Pumping Station - Native Soil in Levee

<u>Elevation</u>	<u>Term</u>	<u>phi</u>	<u>c</u>
Top of Levee to 716	Short	0	1200
"	Long	27	0
716 to 714	Short	0	500
"	Long	28	0
714 to 710	Short	0	1200
"	Long	27	0
710 to 706	"	28	0
706 to 696	"	30	0
696 to 670	"	32	0

# LIVE LOADS

13. In the design of vertical walls below grade, loading conditions in some instances include surcharge loads on the ground surface. They are derived based on the heaviest piece of machinery likely to be placed on the fill during construction or operation and maintenance of the structure.

14. The live loads for the operating floors of the pumping station are assumed to be 100 psf plus the heaviest work piece placed anywhere on the floor.

## UPLIFT

15. Hydrostatic loading is the conventional triangular distribution of water pressure from the uplift head elevation taken to the desired depth. Uplift head elevation is the general elevation of piezometric head beneath the semi-pervious top blanket as determined by Geotechnical.

Uplift Head  
Elevation

at Toe of Berm

Location

- |     |   |
|-----|---|
| 713 | From sewer treatment plant to Pine Street. This area has relief wells.                      |
| 715 | From just upstream of last relief well at Pine Street, upstream to the end of the project.  |
| 713 | Increasing to El. 729 at 150 feet riverward. At pumping station and Outlet C at Oak Street. |

16. Three categories of loading conditions are in the analysis of structures for stability against flotation, usual, unusual, extreme. In the condition when the uplift head elevation is above the ground surface, that head above the ground surface is dissipated in the thickness of the semi-pervious top blanket of soil. Therefore the submerged weight of the soil in the semi-pervious layer will be decreased by the hydrostatic pressure at the ground surface caused from the uplift head.

## PRECAST REINFORCED CONCRETE PIPE

17. Pipe class is according to ASTM C76 and C 655 and shall meet the strength test requirements under the three-edge-bearing method for the specified D-load to produce a 0.01-inch crack. The factor of safety for pipes in the levee is 2.0.

## STRUCTURES

### PUMPING STATION

18. The top slab elevation was established for this projects conditions by Mechanical. It has hatches to allow access to the sump for pulling the pumps and for access by ladder to the platform below. The top slab elevation above the forebay area was established at close to ground surface elevation. Steel grated openings in the slab will allow for cleaning the trash racks and removal of sluice gates. Two access hatches are provided with a ladder to the forebay floor below. The sluice gate stems extend to the gate lifters on this slab. The spacing and top elevation of the sump separator walls was determined for proper operation of the pumps by Mechanical. These walls could

have been full height, but they are not needed for support of the top slab. The wall thicknesses were determined using the proper loading conditions for water and soil.

19. The superstructure walls consist of a monolithic reinforced concrete structural frame and brick masonry skin. The roof system will be supported on the concrete walls. Strength and constructibility determine the wall thickness. The pump hoist will run on a monorail beam. The monorail beam will be supported on concrete wall brackets on both ends and near the middle by a steel beam. The steel beam is supported on both ends on concrete wall brackets, also. All member sizes in the superstructure were determined based on experience and not analysis.

20. There are many miscellaneous structural items in the pumping station which are not sized and detailed. The following is a list of most of these: flange back sluice gates with stem and F type thimble, gate lifters, ladders, platform, grating, handrail, hatch covers and trash rack.

21. The pump station was analyzed for stability against flotation. Base slab extensions were used in addition to the weight of the structure to achieve the proper factor of safety. Overturning and sliding were not checked since the difference in ground surface from front to back is only 3 to 5 feet.

#### OUTLETS

22. There are two gravity outlets on this project. Outlet B is near Chestnut Street and Outlet C is near Oak Street at the pumping station. The outlet consist of a manhole at the interceptor, gravity pipe, gatewell, outlet pipe and sheetpile cutoff wall at the outlet scour hole.

23. The gatewells are located in the levee with the top elevation at top of levee. A sluice gate provides closure from high river water. A bulkhead provides emergency closure. The top slab has hinged steel panels to provide access to the bulkhead area. Steel grating openings will allow removal of sluice gates for maintenance and to allow access to the platforms below by ladder. The wall thicknesses are based on similar gatewells from past designs. The gatewell has access from the top of levee and there are handrails around the top for safety.

24. The crown elevation of the outlet pipes is below the estimated ice line. This established the bottom elevation of the gatewells. The outlet invert elevation is submerged above the bottom of the river channel. The pipe shall have sloped end sections at the outlet. The pipe flexible watertight joints will be bell and spigot with o-ring gaskets.

25. Sheet pile walls are used at the outlet to prevent erosion under the pipes. The top of sheet pile shall conform to the bottom of the pipe to prevent movement of material through the cut-off. The wall is designed as though the soil was eroded away to the elevation of the

bottom of the scour hole. The bottom elevation of the sheetpile below the bottom of the scour hole estimated at a depth of 2 times the height above the bottom of scour hole.

#### INTERCEPTOR STORM SEWER SYSTEM

26. The system consists of a reinforced concrete pipe (RCP) interceptor sloping to two gravity outlets and a series of manholes and risers. Inlets take surface run-off and feed it into the risers, manhole or interceptor. Any structure or part of this system must be located a minimum of 1-foot landside of the berm toe in order to not interfere with the berm.

27. The manhole could be used for future expansion of the cities storm sewer system. Where ever possible at interceptor pipe size changes, an increaser is used and a RCP tee with a riser to the ground surface. Otherwise RCP manholes were used. RCP bends are mostly used for changes in direction of the pipe. At the two gravity outlets, large cast-in-place manholes are used to accommodate the large pipe.

28. The interceptor pipe, tees with risers, and manholes have some special considerations to prevent flotation. A concrete arch is used over the pipe, when required, for added weight between manholes 1 and 3 and at most of the tee sections. At manholes, larger base slabs were used, when required, in order to use the soil above the base slab as weight to achieve the proper factor of safety.

29. The inlets are rectangular reinforced concrete structures with grated tops to let in surface run-off. Standard cast iron castings are used for long life and economic reasons. Since the inlets are relatively shallow and open to the surface, resisting flotation is difficult. Therefore a minimum of 2 feet of pervious fill with drainage gravel at the ground surface is used around the structure and feeder pipe, which prevents the hydrostatic uplift head elevation from being any higher than the top of the inlet. The wall and slab thicknesses were determined for strength and weight to resist flotation.

#### RELIEF WELL SYSTEM

30. A 48" diameter manhole houses and protects the tops of the wells located in the levee berm. The top of the stand pipes at Elevation 706 is approximately 7 feet below the top of berm. Water from the well drains into the interceptor through a 12" RCP. An aluminum check valve, rubber gasket, and plastic standpipe are used to allow escape of water and prevent backflooding of surface water. A stainless steel well screen is used because of its corrosion resistance and efficient screen that can be fabricated.

## PEDESTRIAN/WHEELCHAIR RAMP

31. The ramp between the top of levee and the pedestrian bridge is designed for handicap access with proper slope, landings and handrails. The portion of the existing timber bridge that would be under the new levee will be removed. This will consist of removing the handrail, planking, beams and two pile bents to a minimum of 3-feet below existing grade.

## DESIGN COMPUTATIONS

32. The purpose of the computations is to show loading assumptions, design methods, design criteria and level of detail used in designing the structures. The sample computations shown for the flotation analysis and design of the interceptor and manholes represent the design used for all the structures in the system. Design of the gatewells, outlet and structural steel items were based on experience with other similar projects and no computations are presented for these structures.

33. The structural computations are arranged as shown in the following table of contents.

<u>Item</u>	<u>Page No.</u>
Pumping Station Design	1-19
Inlet Design	20-32
Interceptor Pipe Class Design	33-36
Interceptor and Tee Flotation Analysis	37-48
Manhole Flotation Analysis	49-52
Minimum Angle Between Pipes In Manholes	53-54

## REFERENCES

34. Loading conditions, design assumptions and design methods are based on applicable parts of the following references.

- a. ACI 318-89 American Concrete Institute, "Building Code Requirements for Reinforced Concrete".
- b. AISC, American Institute of Steel Construction, "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings", 9th Edition.
- c. American Concrete Pipe Association, "Concrete Pipe Design Manual", 1978.
- d. EC 1110-2-267, Strength Design for Reinforced Concrete Hydraulic Structures (31 Jan 90)



- e. EM 1110-1-2101, Working Stresses for Structural Design (1 Nov. 63)
- f. EM 1110-2-2000, Standard Practice for Concrete (5 Sept 85)
- g. EM 1110-2-2102, Waterstops and Other Joint Materials (31 May 83)
- h. EM-1110-2-2400, Structural Design of Spillway Outlet Works (2 Nov 64)
- i. EM 1110-2-2502, Retaining and Flood Walls (29 Sept 89)
- j. EM 1110-2-2902, Conduits, Culverts and Pipes (Mar 1969)
- k. EM 1110-2-2906, Design of Pile Structures and Foundations (July 1969 and Nov 1970)
- l. EM 1110-2-3104, Structural & Architectural Design of Pumping Stations (30 June 89)
- m. ETL 1110-2-256, Sliding Stability for Concrete Structures (June 1981)
- n. ETL 1110-2-307, Flotation Stability Criteria for Concrete Hydraulic Structures (Aug 1987)
- o. Engineering Monograph No. 27, Moments and Reactions for Rectangular Plates, by W.T. Moody, U.S. Bureau of Reclamation.
- p. Uniform Federal Accessibility Standards, FED-STD-795, 1 Apr 88

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# Pump Station

## Determine Wall Thickness

Uplift head 28' from berm toe

$$H = \frac{28'}{150'} \times 16' + 713 = 716$$

Use for pump chamber walls

$$K_{op} = (1 - \sin \phi)(1 + \sin \beta) [EM 1110-2-2502, 3-10]$$

$$\gamma_{sat} = 125 \text{ pcf}$$

El. 713:

$$P = (62.5)(3') = 187.5 \text{ psf}$$

El. 710:

$$P = P_{713} + [(62.5 + (72)(125 - 62.5))(3')] = 187.5 + 322.5 = 510 \text{ psf}$$

El. 706:

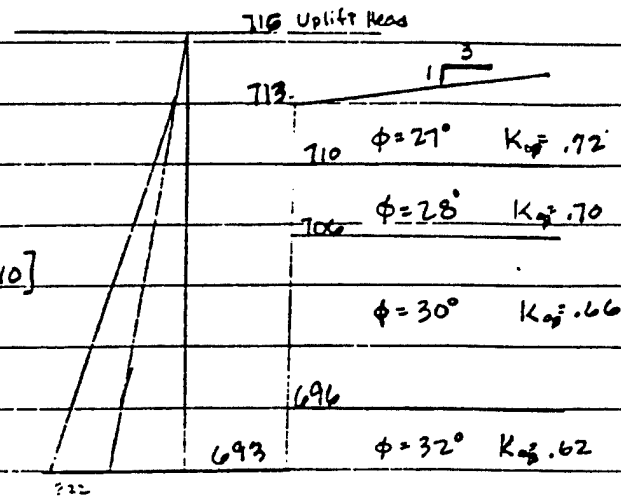
$$P = P_{710} + [(62.5 + (70)(125 - 62.5))(4')] = 510 + 425 = 935 \text{ psf}$$

El. 696:

$$P = P_{706} + [(62.5 + (66)(125 - 62.5))(10')] = 935 + 1037.5 = 1972.5 \text{ psf}$$

El. 693:

$$P = P_{706} + [(62.5 + (62)(125 - 62.5))(3')] = 1972.5 + 303.75 = 2276 \text{ psf}$$



REFERENCE: MONOGRAPH OF TABLES USED FOR RECTANGULAR PLATES + SLAB - MOMENT + SHEAR COEFF.

Side Walls of sump area:

hinged bp because of large openings.

Fixed on 3 sides

$$a/b = \frac{15/2}{20.5} = .37, X_A = 0, Y/b = .64, M_A$$

$$\text{Figure 10 (Coeff): } \begin{matrix} \text{max.} \\ \text{Coeff} \end{matrix} \begin{matrix} .0403 \\ \text{Mom} = .0374 \end{matrix} \begin{matrix} .3624 \\ \text{Reaction} = .3427 \end{matrix}$$

$$\text{Figure 13 (Coeff): } \begin{matrix} \text{max.} \\ \text{Coeff} \end{matrix} \begin{matrix} .0170 \\ \text{Mom} = .0207 \end{matrix} \begin{matrix} .2120 \\ \text{Reaction} = .2647 \end{matrix}$$

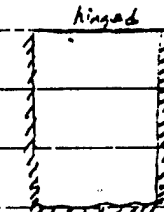
$$\text{Max. } M = (.0403)(1875)(20.5)^2 + (.0170)(2089)(20.5)^2 = 10.10 \text{ k} \leftarrow = 254 \text{ k}$$

$$M_u = 1.7 \times 1.3 \times 254 \text{ k} = 560 \text{ k}$$

Hydraulic Structure EM-1110-2-XXXX

$$f_{max} = 125 \text{ psi} = .007126 = \frac{A_s}{b h}, 18" \text{ wall } A_{s \text{ req}} = .007126 \times 12 \times 18 = 1.54 \text{ in}^2$$

$$\phi M_u = \phi f_y A_s \left( d - \frac{A_s f_y}{1.7 b f_c} \right) = (.9)(60)(1.5) \left[ 14.5 - \frac{(1.5)(60)}{(17)(2)(4)} \right] = 1085 \text{ k} > 560 \text{ k (ok)}$$



## Pump station

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Determine wall thickness (cont)

$$\text{Max. Shear} = \frac{(1.3624)}{(1.3421)} \frac{(1.2120)}{(1.1875)} = 10.47^k$$

$$\text{Max. Shear} = (1.3421)(1.1875)(20.5) + (1.2647)(2.089)(20.5) = 12.65^k \leftarrow$$

$$V @ \text{dr out from support} = 12.65 - [(1.1875) + (1.946) + (\frac{1}{2})(1.123)] (\frac{14.5}{12}) = 12.65 - 2.68 = 9.97^k$$

$$V_u = 1.7 \times 1.3 \times 9.97^k = 22.0^k$$

Try 24" wall  $d = 24 - 3.5 = 17.5"$ 

$$\phi V_u = \phi d b \sqrt{\frac{f_c}{2}} = (1.85)(12)(17.5)(126) = 22.6^k \sim 22.0^k \text{ (OK) 24" wall min.}$$

Use 24" wall - exterior side pump chamber walls

(Need extra wt. for uplift.)

Determine exterior endwall thickness for sump area.

SPAN HORIZONTALLY 5' BETW. WALLS

Neg. moment  $\frac{1}{12} w l^2$  do at 12" above floor

$$w = 2.175^k/ft, \quad l = 5' \text{ clear span}$$

$$M_{max} = (\frac{1}{12})(2.175)(5)^2 = 4.53^{in} = 54.4^{in}$$

$$M_u = 1.7 \times 1.3 \times 54.4 = 120^{in} ; p_{max} = .25 p_b = .007126 \quad \text{Try } h = 14", d = 10.5"$$

$$\phi M_n = \phi p f_y b d^2 (1 - \frac{p f_y}{17 f_c}) = (.9)(.007126)(60) (\frac{1 - (.007126)(60)}{17.7(4)}) (12)(10.5)^2 = 312^{in} > 120^{in} \text{ (OK) for 14" wall}$$

$$V = (2.175)(\frac{5}{2}) = 5.44^k, \quad V_u = 1.7 \times 1.3 \times 5.44 = 12^{in}$$

$$\phi V_u = (.85)(126)(12)(10.5) = 13.5^k > 12^k \text{ (OK)}$$

Span horizontally 18' above El. 706.5

Neg. moment  $\frac{1}{12} w l^2$  take load at El. 706

$$w = (\text{from load diagram on previous sheet}) .935^k/ft, \quad l = 18' \text{ clear span}$$

$$M_{max} = (\frac{1}{12})(.935)(18)^2 = 25.25^{in} = 303^{in}$$

$$M_u = 1.7 \times 1.3 \times 303^{in} = 670^{in} \quad p_{max} = .007126$$

$$\phi M_n = (.9)(.007126)(60) (\frac{1 - (.007126)(60)}{17.7(4)}) (12) d^2 = 4.33 d^2$$

Try 16" wall  $d = 16 - 3.5 = 12.5"$ 

$$\phi M_n = 4.33 (12.5)^2 = 676^{in} > 670^{in} \text{ (OK) } \frac{D-9}{(OK)}$$

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## Pump Station

Wall thickness (in)

$$V = (935) \left( \frac{18}{2} \right) = 8.42^k$$

$$\phi V_c = (85)(.126)(2) d = 1.29 d$$

Assume 16" wall  $d = 12.5"$ 

$$V_{\text{dent}} = 8.42 - \left( \frac{12.5}{18} \right) (935) = 8.42 - .97 = 7.45$$

$$V_u = 7.45 \times 1.7 \times 1.3 = 16.5^k$$

$$\phi V_c = 1.29(12.5) = 16.2^k \sim 16.5 \text{ (ok) } 16" \text{ wall}$$

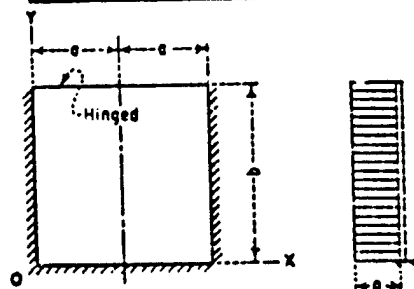
Use 24" wall exterior and at pump chamber - need for weight.

Use 16" min wall thickness for exterior walls (structure above is 16" wall)

Walls &gt; 10' high min 14" thick

## MOMENTS AND REACTIONS FOR RECTANGULAR PLATES

	$y/b$	$y_0 \rightarrow$	$M_x$						$M_y$					
			0	0.2	0.4	0.6	0.8	1.0	0	0.2	0.4	0.6	0.8	1.0
$a/b = 1/8$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0
$a/b = 1/4$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0
$a/b = 3/8$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0
$a/b = 1/2$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0
$a/b = 3/4$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0
$a/b = 1$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0
$a/b = 3/2$	1.0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.8	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.6	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.4	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0.2	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	0	$\rightarrow$	0.063	0	0	0	0	0	0	0	0	0	0	0
	$R_y \rightarrow$		0.063	0	0	0	0	0	0	0	0	0	0	0



Moment = (Coefficient)( $pb^2$ )  
Reaction = (Coefficient)( $pb$ )

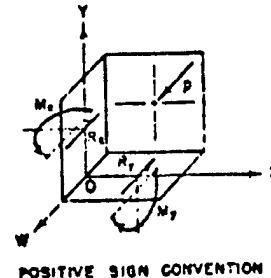
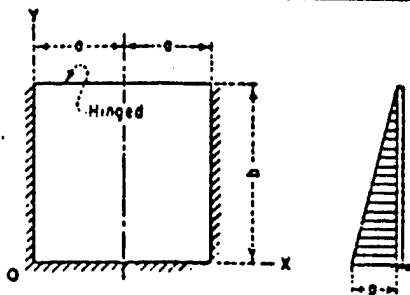


FIGURE 10.—Plate fixed along three edges—Hinged along one edge, moment and reaction coefficients. Load  $p$ , uniform load.

## RESULTS

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	$1/b$	$1/a$	$M_x$						$M_y$					
			0	0.2	0.4	0.6	0.8	1.0	0	0.2	0.4	0.6	0.8	1.0
$a/b = 1/8$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.0250	+0.0010	+0.0005	+0.0000	-0.0003	-0.0005	-0.0005	+0.0002	+0.0001	+0.0000	-0.0001	-0.0001	-0.0001
	0.6	+0.0500	+0.0021	+0.0009	+0.0001	-0.0006	-0.0009	-0.0011	+0.0004	+0.0002	+0.0000	-0.0001	-0.0002	-0.0002
	0.4	+0.0752	+0.0031	+0.0014	+0.0001	-0.0008	-0.0014	-0.0016	+0.0006	+0.0003	+0.0000	-0.0002	-0.0003	-0.0003
	0.2	+0.0941	+0.0038	+0.0016	+0.0000	-0.0010	-0.0017	-0.0019	+0.0008	+0.0003	-0.0001	-0.0003	-0.0003	-0.0003
	0	+0.0459	0	+0.0031	+0.0003	+0.0005	+0.0006	+0.0006	0	+0.0005	+0.0014	+0.0023	+0.0028	+0.0030
$a/b = 1/4$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	1.0	-0.0661	0	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.0505	+0.0042	+0.0019	+0.0001	-0.0011	-0.0018	-0.0021	+0.0008	+0.0004	+0.0000	-0.0002	-0.0004	-0.0005
	0.6	+0.1020	+0.0082	+0.0037	+0.0002	-0.0023	-0.0037	-0.0042	+0.0016	+0.0007	-0.0000	-0.0006	-0.0010	-0.0011
	0.4	+0.1517	+0.0114	+0.0049	+0.0000	-0.0032	-0.0051	-0.0057	+0.0023	+0.0009	-0.0004	-0.0013	-0.0019	-0.0021
	0.2	+0.1495	+0.0102	+0.0037	-0.0004	-0.0030	-0.0043	-0.0047	+0.0020	+0.0004	-0.0011	-0.0022	-0.0029	-0.0031
$a/b = 3/8$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	1.0	-0.0205	0	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.0788	+0.0091	+0.0039	+0.0001	-0.0026	-0.0041	-0.0046	+0.0018	+0.0007	-0.0003	-0.0010	-0.0015	-0.0016
	0.6	+0.1550	+0.0170	+0.0070	-0.0001	-0.0048	-0.0075	-0.0084	+0.0034	+0.0011	-0.0009	-0.0025	-0.0035	-0.0038
	0.4	+0.2120	+0.0207	+0.0078	-0.0008	-0.0061	-0.0089	-0.0098	+0.0041	+0.0009	-0.0021	-0.0044	-0.0058	-0.0063
	0.2	+0.1696	+0.0145	+0.0045	-0.0012	-0.0042	-0.0057	-0.0061	+0.0029	+0.0001	-0.0023	-0.0039	-0.0049	-0.0052
$a/b = 1/2$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	1.0	-0.0596	0	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.1042	+0.0139	+0.0053	-0.0005	-0.0041	-0.0060	-0.0067	+0.0028	+0.0006	-0.0014	-0.0030	-0.0040	-0.0044
	0.6	+0.1956	+0.0245	+0.0087	-0.0013	-0.0073	-0.0104	-0.0114	+0.0049	+0.0008	-0.0031	-0.0062	-0.0082	-0.0089
	0.4	+0.2450	+0.0269	+0.0085	-0.0023	-0.0081	-0.0110	-0.0119	+0.0054	+0.0001	-0.0048	-0.0085	-0.0108	-0.0116
	0.2	+0.1632	+0.0159	+0.0039	-0.0019	-0.0044	-0.0054	-0.0057	+0.0032	-0.0003	-0.0029	-0.0043	-0.0050	-0.0052
$a/b = 3/4$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	1.0	-0.0671	0	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.1275	+0.0181	+0.0044	-0.0026	-0.0058	-0.0071	-0.0074	+0.0036	-0.0008	-0.0031	-0.0085	-0.0106	-0.0113
	0.6	+0.2274	+0.0301	+0.0065	-0.0048	-0.0097	-0.0115	-0.0119	+0.0060	-0.0019	-0.0094	-0.0150	-0.0185	-0.0196
	0.4	+0.2616	+0.0302	+0.0051	-0.0055	-0.0095	-0.0107	-0.0109	+0.0060	-0.0030	-0.0106	-0.0158	-0.0188	-0.0198
	0.2	+0.1479	+0.0155	+0.0017	-0.0027	-0.0035	-0.0033	-0.0032	+0.0031	-0.0011	-0.0027	-0.0027	-0.0023	-0.0021
$a/b = 1$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	1.0	-0.0764	0	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.1300	+0.0177	+0.0016	-0.0043	-0.0060	-0.0062	-0.0061	+0.0055	-0.0028	-0.0086	-0.0127	-0.0150	-0.0153
	0.6	+0.2289	+0.0289	+0.0019	-0.0074	-0.0097	-0.0092	-0.0096	+0.0058	-0.0054	-0.0149	-0.0213	-0.0246	-0.0259
	0.4	+0.2583	+0.0280	+0.0006	-0.0076	-0.0089	-0.0086	-0.0084	+0.0056	-0.0064	-0.0152	-0.0203	-0.0228	-0.0235
	0.2	+0.1417	+0.0137	-0.0003	-0.0027	-0.0022	-0.0015	-0.0012	+0.0027	-0.0016	-0.0019	-0.0008	+0.0003	+0.0007
$a/b = 3/2$	$R_1/P_1$	$R_2/P_2$	-0.003	+0.003	+0.004	+0.005	+0.006	+0.007	0	0	0	0	0	0
	$R_1$	$R_2$	-0.003	0	0	0	0	0	0	0	0	0	0	0
	1.0	-0.0743	0	0	0	0	0	0	0	0	0	0	0	0
	0.8	+0.1257	+0.0145	-0.0025	-0.0055	-0.0052	-0.0046	-0.0044	+0.0029	-0.0067	-0.0134	-0.0169	-0.0183	-0.0187
	0.6	+0.2208	+0.0232	-0.0046	-0.0089	-0.0091	-0.0072	-0.0069	+0.0046	-0.0118	-0.0223	-0.0273	-0.0292	-0.0297
	0.4	+0.2503	+0.0219	-0.0022	-0.0082	-0.0071	-0.0061	-0.0058	+0.0044	-0.0123	-0.0207	-0.0240	-0.0251	-0.0253
	0.2	+0.1461	+0.0121	-0.0022	-0.0018	-0.0025	-0.0022	-0.0024	+0.0020	-0.0019	-0.0002	+0.0017	+0.0026	+0.0029



Moment = (Coefficient)( $pb^2$ )  
Reaction = (Coefficient)( $pb$ )

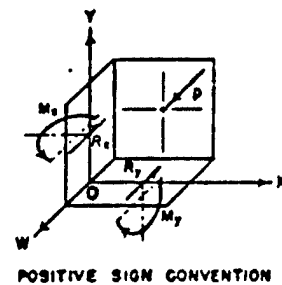


FIGURE 13.—Plate fixed along three edges—Hinged along one edge, moment and reaction coefficients, Load IV, uniformly varying load.

NRH 12/31/90

✓GRS 1/91

## Pump Station

Determine Wall Thickness

Forebay

End wall

$$K_0 = 1 - \sin \phi$$

$$\gamma_{sat} = 125 \text{ pcf}$$

El. 710:

$$p = (62.5)(3') = 187.5 \text{ psf}$$

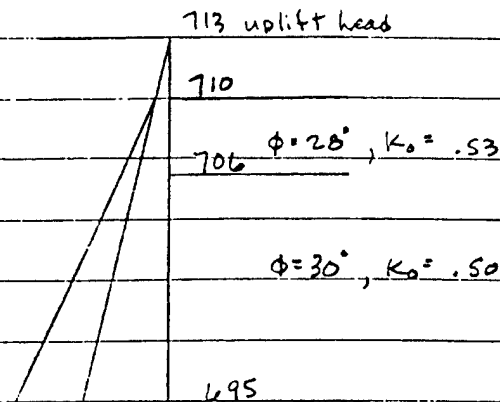
$$709: p = 187.5 + 95.5 = 283$$

El. 706:

$$p = p_{710} + [(62.5 + (.53)(125 - 62.5))(4')] = 187.5 + 382.5 = 570 \text{ psf}$$

El. 695:

$$p = p_{706} + [(62.5 + (.50)(125 - 62.5))(11')] = 570 + 1030 = 1600 \text{ psf}$$



Reference: Monograph of Tables used for rectangular plates + slabs - moment + shear coeff.

Hinged at top because of large openings, fixed 3 sides.

$$a/b = \frac{18/2}{14} = .64, \text{ figure 10 + 13 for worst case.}$$

Reactions - worst case:  $R_y @ \frac{x}{a} = 1.0$ 

$$\text{figure 10: } R_y = .5304$$

$$\text{figure 13: } R_y = .3563$$

$$\text{Max shear} = [(.5304)(.283) + (.3563)(.1317)](14) = 8.67^k \quad \text{assume } 16", d = 12.5"$$

$$\text{Ved out from support} = 8.67 - [(.283) + (.1219 + (\frac{1}{2})(.0992))](\frac{12.5}{16}) = 8.67 - 1.62 = 7.05^k$$

$$V_u = 1.7 \times 1.3 \times 7.05^k = 15.6^k$$

$$\phi V_c = 1.29(12.5) = 16.2^k > 15.6^k \text{ (ok) } 16" \text{ min wall}$$

use = " Moments - worst case:  $M_y @ \frac{x}{a} = 1.0, \frac{y}{b} = 0$ 

$$\text{figure 10: } M_y = .0728; \text{ figure 13: } M_y = .0424$$

$$\text{Max. Mom.} = [(.0728)(.283) + (.0424)(.1317)](14)^2 = 14.97^{1k} \approx 180^{1k}$$

$$M_u = 1.7 \times 1.3 \times 180 = 397^{1k}$$

Hydraulic Structures EM 1110-2-XXXX

$$p_{max} = .25 p_u = .007126 \quad 16" \text{ wall, } d = 12.5"$$

$$\phi M_n = \phi p f_y (1 - \frac{p f_y}{1.7 f'_c}) b d^2 = 4.33 d^2 = (.933)(12.5)^2 = 676^{1k} > 397^{1k} \text{ ok}$$

Use 24" wall - Exterior Wall In let Chamber (need weight)

NRH 12/31/90

GRS 1/91

## Pump Station

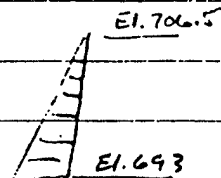
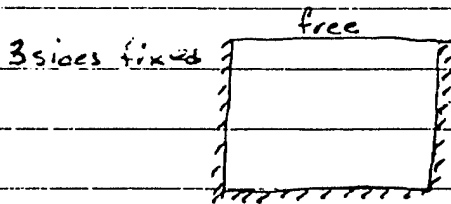
Determine Wall thickness - Interior walls

Wall between Sump area and Forebay

Span 5' betw. walls up to El. 706.5, Hydrostatic head on one side.

By inspection a 16" wall is sufficient. Need 16" to support 16" wall above.

Determine wall thickness of walls between pump chambers up to El. 706.5.



$$p = (62.5)(13.5) = 844 \text{ psf}$$

Use Monograph of Tables used for rectangular plates + slabs - Moment + shear coeff.

$$a/b = \frac{15/2}{13.5} = .56; \text{ Reactions - worst case: } R_y @ x/a = 1.0$$

$$\text{Figure 4: } R_y = .3434 \quad \Delta$$

$$\text{Max. shear} = (.3434)(844)(13.5) = 3.9^k \quad \text{min. } 14", d = 10.5"$$

$$V_{\text{out}} = 3.9 - [.789 + (.48055)]\left(\frac{10.5}{13.5}\right) = 3.9 - .71 = 3.2^k \times 1.7 = 5.4^k$$

$$\phi V_c = 1.29(d) = (1.29)(10.5) = 13.5^k > 5.4^k \text{ ok} \quad 14" \text{ wall}$$

$$\text{Moment worst case: } M_y @ x/a = 1.0, y/b = 0$$

$$\text{Figure 4: } M_y = .0387 \quad \Delta$$

$$\text{Max Moment} = (.0387)(844)(13.5)^2 = 6.0^{kl} = 71.5^{in}kl$$

$$M_u = 1.7 \times 1.3 \times 71.5 = 158^{in}kl$$

$$\phi M_n = .25 \phi_b = .007126 \quad 14" \text{ wall } d = 10.5$$

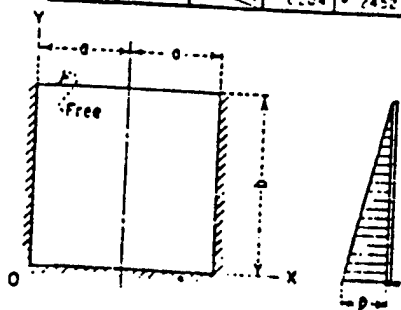
$$\phi M_n = 4.33d^2 = (4.33)(10.5)^2 = 477^{in}kl > 158^{in}kl \text{ ok}$$

Use 14" wall between pump chambers.

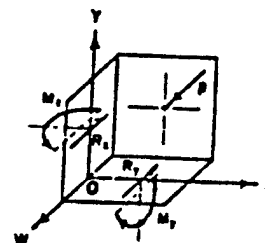


## MOMENTS AND REACTIONS FOR RECTANGULAR PLATES

	$y/b$	$\frac{y}{b}$	$M_x$						$M_y$					
			0	0.2	0.4	0.6	0.8	1.0	0	0.2	0.4	0.6	0.8	1.0
$a/b = 1/8$	1.0	0.062	0.004	0.002	0.000	0.000	0.000	0.000	0	0	0	0	0	0
	0.8	0.075	0.011	0.005	0.000	0.000	0.000	0.000	0	0	0	0	0	0
	0.6	0.096	0.021	0.009	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.075	0.031	0.014	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.042	0.038	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.060	0	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$a/b = 1/4$	1.0	0.147	0.022	0.012	0.002	0.000	0.000	0.000	0	0	0	0	0	0
	0.8	0.052	0.046	0.022	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.6	0.105	0.083	0.037	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.151	0.114	0.049	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.149	0.102	0.037	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.030	0	0.004	0.010	0.016	0.020	0.021	0	0.020	0.052	0.081	0.100	0.107
$a/b = 3/8$	1.0	0.189	0.056	0.030	0.008	0.000	0.000	0.000	0	0	0	0	0	0
	0.8	0.085	0.117	0.055	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.6	0.151	0.176	0.075	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.207	0.208	0.079	0.007	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.163	0.145	0.045	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.102	0	0.009	0.020	0.030	0.035	0.040	0	0.039	0.099	0.152	0.188	0.200
$a/b = 1/2$	1.0	0.326	0.151	0.088	0.015	0.004	0.000	0.000	0	0	0	0	0	0
	0.8	0.135	0.216	0.099	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.6	0.192	0.273	0.161	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.242	0.277	0.092	0.019	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.160	0.160	0.041	0.017	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.045	0	0.004	0.033	0.050	0.061	0.065	0	0.068	0.167	0.252	0.307	0.325
$a/b = 3/4$	1.0	0.661	0.454	0.196	0.013	0.000	0.000	0.000	0	0	0	0	0	0
	0.8	0.267	0.433	0.177	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.6	0.408	0.426	0.145	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.242	0.349	0.091	0.039	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.137	0.163	0.031	0.017	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.195	0	0.028	0.064	0.093	0.111	0.117	0	0.139	0.320	0.465	0.554	0.584
$a/b = 1$	1.0	0.985	0.544	0.256	0.016	0.000	0.000	0.000	0	0	0	0	0	0
	0.8	0.264	0.601	0.210	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.6	0.455	0.515	0.149	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.241	0.372	0.078	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.110	0.154	0.025	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.241	0	0.044	0.056	0.037	0.061	0.069	0	0.070	0.220	0.362	0.444	0.474
$a/b = 3/2$	1.0	0.327	0.087	0.027	0.007	0.000	0.000	0.000	0	0	0	0	0	0
	0.8	0.299	0.070	0.018	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.6	0.232	0.060	0.014	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.4	0.148	0.039	0.008	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.2	0.037	0.012	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0	0.204	0	0.079	0.159	0.212	0.243	0.252	0	0.394	0.791	1.062	1.214	1.252



Moment = (Coefficient)( $pb^2$ )  
Reaction = (Coefficient)( $pb$ )



POSITIVE SIGN CONVENTION

FIGURE 4.—Plate fixed along three edges, moment and reaction coefficients, Load  $1V$ , uniformly varying load.

NRH 12/31/90

VGRS 1/91

## Pump Station

Determine thickness of floor slab at El. 714.75

EM 1110-2-3104

Operating Floor: Live Load 100 psf plus floor must be designed to allow placement of the heaviest piece of machinery anywhere on the floor. Heaviest piece of equipment will be a pump. Weight of pump 3000 lbs.

Walls were designed for a hinged connection at top slab (operating floor).

The walls are quite long, so will have reduced fixity. Top of walls may have reduced thickness because of bridge ledge. Therefore assume slab hinged at wall.

$$M = \text{Design Moment} = \frac{wL^2}{8} + \frac{PL}{4}$$

$$L = 15'$$

$$w = 100 \text{ psf} (5' + 1.5') = .65 \text{ k/ft.}$$

$$P = 3000 \text{ lb}$$

$$M = \left(\frac{1}{8}\right)(.65)(15)^2 + \left(\frac{1}{4}\right)(3)(15) = 18.3 + 11.3 = 29.5 \text{ k} = 355 \text{ in-k}$$

$$M_u = 1.7 \times 1.3 \times 355 = 783 \text{ in-k} \quad \text{Hydraulic Structure}$$

$$\phi M_n = \phi \rho f_y \left(1 - \frac{\rho f_y}{1.7 f_c}\right) b d^2 \quad \text{Strength Design Manual}$$

$$f'_c = 4000 \text{ psi}, f_y = 60,000 \text{ psi}, \phi = .9, b = 18", \rho_{max} = .25 \rho_b = .007126$$

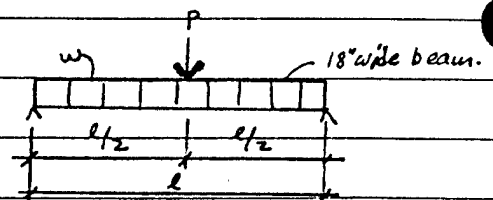
$$\phi M_n = (.9)(.007126)(60) \left[1 - \frac{(.007126)(60)}{1.7(4)}\right] (b)(d)^2 = .36(18) d^2; d_{min} = \sqrt{\frac{783}{.36}} = 11.0' + 3.5 = 14.5' \sim 15' \text{ slab}$$

$$\phi M_u = 6.49(11.5) = 858 \text{ in-k} > 783 \text{ in-k (OK)} \rightarrow \text{Use 15" thick slab on operating floor El. 714.75}$$

$$\text{Max. shear (move load P to end)} = \frac{wL}{2} + P = (.65)(7.5) + 3 = 7.88 \text{ k}$$

$$V_u = 1.7 \times 1.3 \times 7.88 = 17.4 \text{ k @ support}$$

$$\phi V_c = \phi .126 b d \sqrt{f'_c} = (.126)(18)(11.5) = 22.2 \text{ k} > 17.4 \text{ (OK)}$$



Pump Station

VGRS 1/91

Forebay slab El. 710

There is a wall around the Forebay top slab so vehicles cannot be on this slab.

The heaviest equipment on this floor will be a sluice gate.

Weight of sluice gate approx. 3000<sup>#</sup>.

The size of the forebay area is <sup>the</sup> same (or very similar) to the sump area.

Therefore the design will be the same as the Sump Area top slab El. 714.75.

Use 14" slab.

Check slab for gate operator

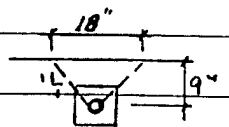
Based on manufacturer catalogs for 48" x 48" gate

Operator lifting force = 8000<sup>#</sup> F.S.S (EM1110-2-3104)  $F = 8000 \times 5 = 40^k$

distance<sup>2</sup> stem to wall = 9"

Moment =  $40^k \times 9" = 360^k \text{ in}$  ,  $M_u = 1.7 \times 1.3 \times 360^k \text{ in} = 796^k \text{ in}$

Shear =  $40^k$  ,  $V_u = 1.7 \times 1.3 \times 40^k = 88^k$

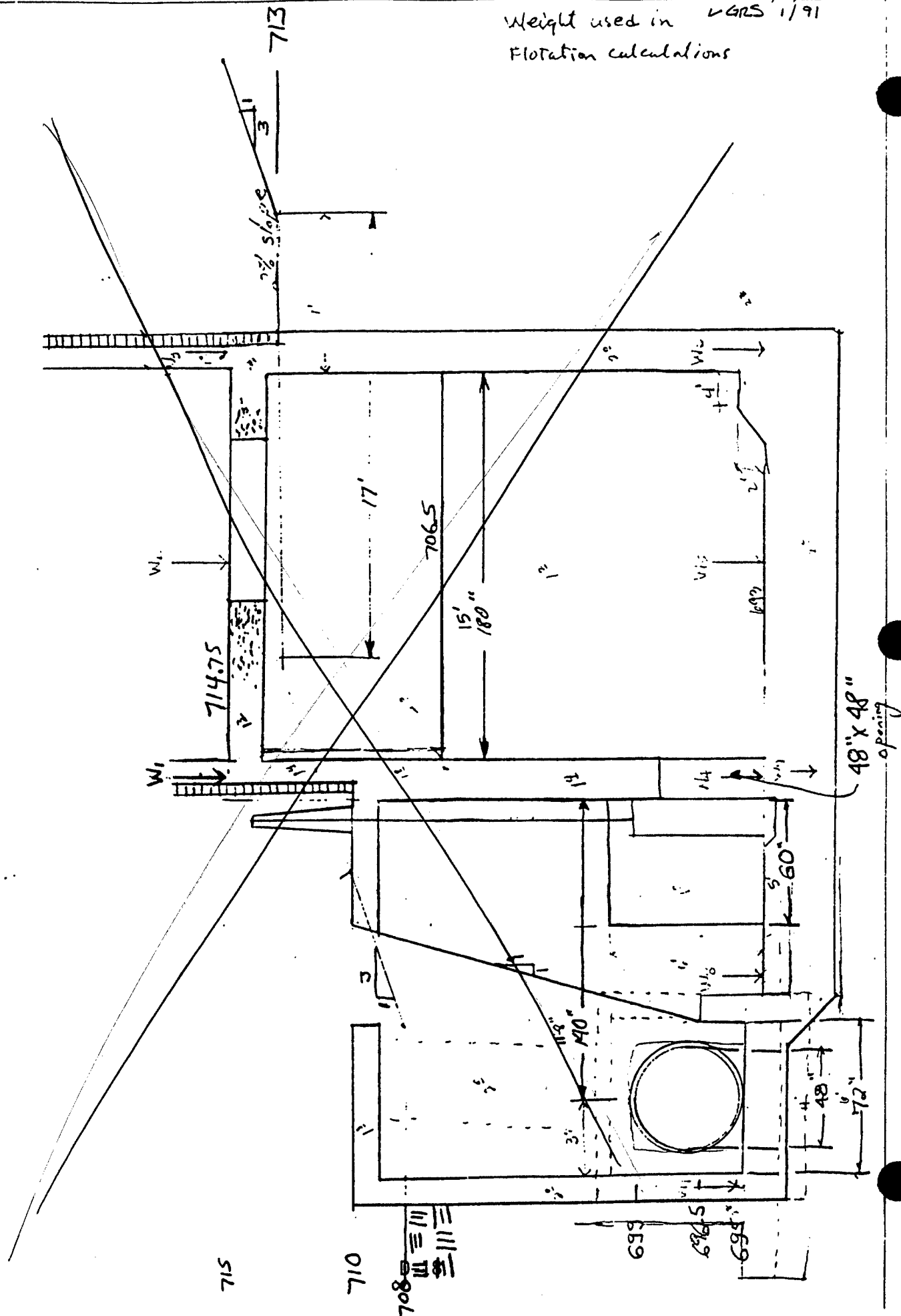


$\phi M_n = .36 b d^2$  ( $d = 14 - 2.5 = 11.5$ ) =  $(.36)(18)(11.5)^2 = 857^k \text{ in} > 796^k \text{ in}$  15" slab ok

Shear - friction

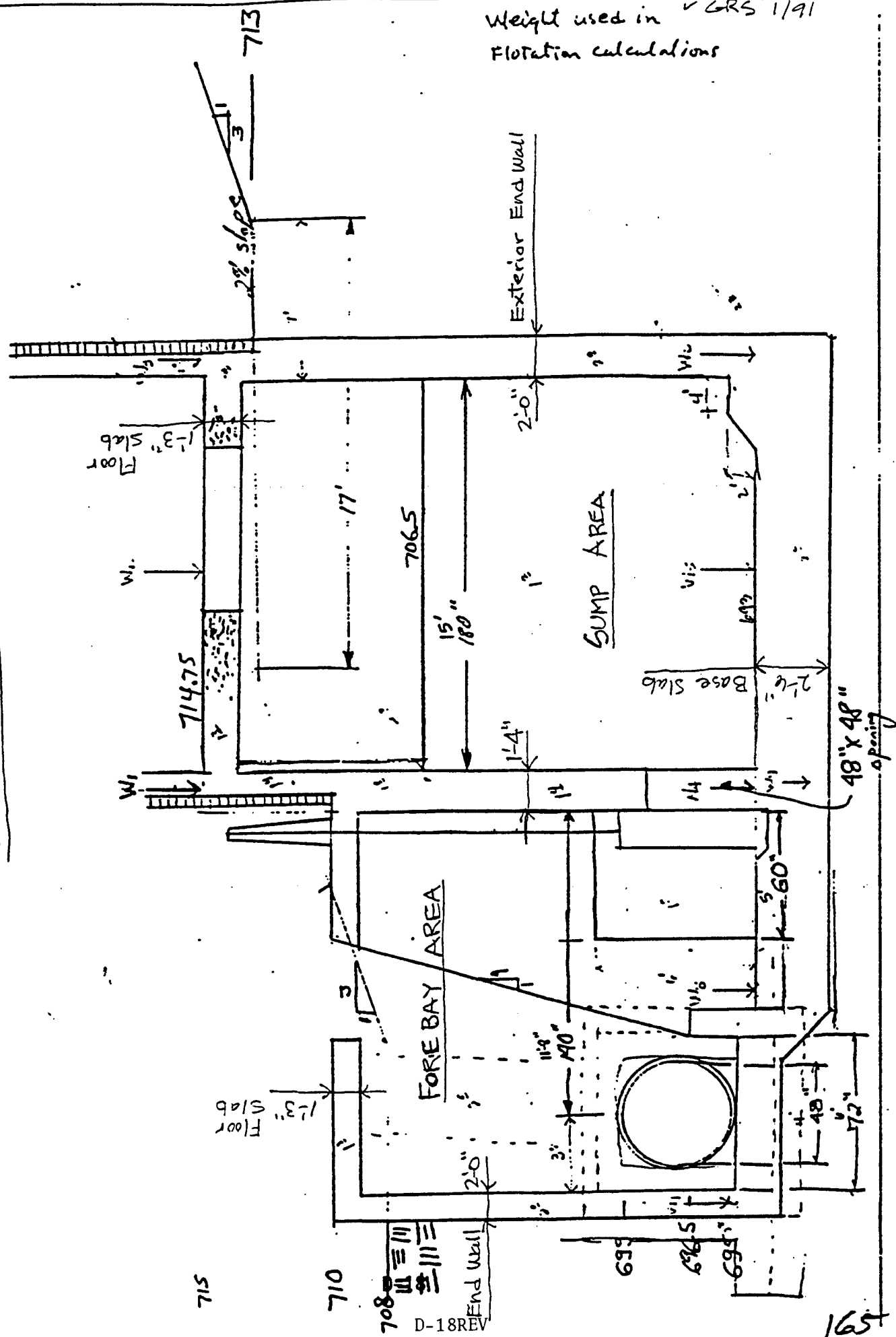
ACI 11.7.5  $\phi V_c = \phi .2 f'_c b d = \phi .8 b d = (.68)(18)(11.5) = 140^k > 88^k$  (ok)

$A_{vf} = \frac{V_u}{\phi f_y \mu} = \frac{(88)}{(.65)(60)(1.4)} = 1.23 \text{ in}^2 / 18" \text{ width}$  15" slab (ok)



Weight used in  
Flotation calculations

# PUMP STATION



NRH 1/3/91

LGRS 1/91

## Pumping Station

Weight (dead load) used for flotation calculations -

## Concrete:

 $W_1 = W_3$  : Roof + walls superstructure

$$\text{Roof dead load (assume spsf)} : (5) \left( \frac{18'}{2} \right) (27.33') = 1.23$$

$$12" \text{ conc. wall} : (150 \text{ pcf}) (1') (12') (27.33') = 49.19$$

$$4" \text{ brick wall} : (40 \text{ pcf}) (12') (27.33') = 13.12$$

$$W_1 = W_3 = 63.54^k$$

 $W_2$  : walls - superstructure

$$12" \text{ conc. wall} : (150 \text{ pcf}) \left[ (1') (12') (15.33')^2 - (\text{door}) (1') (10' \times 6') \right] = 46.19$$

$$4" \text{ brick wall} : (40 \text{ pcf}) \left[ (12') (15.33')^2 - (\text{door}) (10' \times 6') \right] = 12.32$$

$$W_2 = 58.50^k$$

 $W_4$  : conc. walls substructure

$$4" \text{ Brick} : (40 \text{ pcf}) (4.75') (27.33') = 5.19$$

$$16" \text{ conc. wall} : (150 \text{ pcf}) (1.33') \left[ (4.75' \times 22') + (9.75') (5.33') \right] = 31.22$$

$$20" \text{ conc. wall} : (150 \text{ pcf}) (1.67') (3.5') (22') = 19.29$$

$$16" \text{ wall} : (150) (1.33) \left[ (13.5') (22') - (4') (4') (3') \right] = 49.68$$

$$W_4 = 105.38$$

 $W_5$  : 2 exterior walls + 2 interior walls + 714.75 slab + 1 grade beam - Substructure

$$24" \text{ walls} : (150 \text{ pcf}) (2') (5') (21.75') (2) = 195.75$$

$$14" \text{ walls} : (150 \text{ pcf}) (1.17') (5') (13.50') (2) = 71.08$$

$$15" \text{ slab} : (150 \text{ pcf}) (1.25') \left[ (15') (18' + 4') - (5' \times 6' \times 3) - (2.5') (2.5') \right] = 43.83$$

$$16" \text{ grade beam} : (150 \text{ pcf}) (1.33') (5') (5') = 14.96$$

$$W_5 = 325.62$$

NRH 1/4/91

✓GRS 1/91

## Pumping Station

## Weight (cont)

 $W_6$ : exterior wall + grade beam - substructure

$$24" \text{ wall: } (150 \text{ pcf}) (2') (22') (21.75') = 143.55$$

$$16" \text{ grade beam: } (150 \text{ pcf}) (1.33') (5') (5.33') = 5.32$$

$$W_6 = 148.87^k$$

 $W_7$ : exterior wall - substructure + brick wall - superstructure

$$24" \text{ wall: } (150 \text{ pcf}) (2') (22') (15') = 99.00$$

$$4" \text{ brick wall: } (40 \text{ pcf}) (3') (22') = 2.64$$

$$W_7 = 101.64^k$$

 $W_8$ : 2 exterior walls + 2 small interior walls + 710 slab - substructure + brick wall - superstructure

$$24" \text{ walls: } (150 \text{ pcf}) (2') [(6')(15') + (9.67')(17')](2) = 142.43$$

$$12" \text{ walls: } (150 \text{ pcf}) (1') [(6')(5')(2) + (11.5')(18')] = 13.05$$

$$15" \text{ slab: } (150 \text{ pcf}) (1.25') [(14.67')(18') - (3')(5' \times 3')] = 41.07$$

$$4" \text{ brick wall: } (40 \text{ pcf}) (3') (16.67' + 10') = 3.20$$

$$W_8 = 199.75^k$$

 $W_9$ : Base Slab - Substructure

$$36" \text{ slab: } (150 \text{ pcf}) (3') (22') (35') = 346.5$$

$$W_9 = 346.5$$

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NRH 1/4/91

✓ GRS 1/91

## Pumping Station

### Weight for Flotation (cont)

#### WE - Wt. of Fixed Equipment

48"x48" sluiceway 2100# x 3 = 6300

pump 3000# x 3 = 9000

motor control center (Electrical) 1 unit = 6000

WE = 21.3K

Ww - Wt. of water to El. 698 (lowest pump operating range) in Forebay.

$(18') \cdot (.0625 \text{ kcf}) [(7')(3') + (7.67')(5')] \quad Ww = 66.77K$

TOTAL Dead Load weight:

= 150.41K



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NRH 1/4/91

✓ GRS 1/91

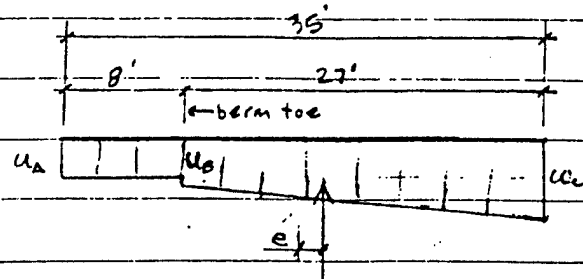
# Pumping Station

UPLIFT EM 1110-2-3104

uplift head at berm toe = El. 713

uplift head toward river =

$$El. 713 + \frac{16'}{150'} (27') = El. 714$$



$$U_A = (713 - 692)(22') (0.0625 \text{ kcf}) = 28.88 \text{ k/ft.}$$

$$U = 1140.67 \text{ k} (1.48 \text{ ksf}) \text{ Avg.}$$

$$U_B = (713 - 690)(22') (0.0625 \text{ kcf}) = 31.63 \text{ k/ft.}$$

$$U_C = (716 - 690)(22') (0.0625 \text{ kcf}) = 35.75 \text{ k/ft.}$$

	distance to center	Mom. abt. center
$U_A = 28.88 (35) = 1010.8 \text{ k}$	0	0
$U_B = (31.63 - 28.88)(27) = 74.25 \text{ k}$	4'	297 <sup>16</sup> / <sub>12</sub>
$U_C = (35.75 - 31.63)(27/2) = 55.62 \text{ k}$	8.5'	472.77 <sup>16</sup> / <sub>12</sub>
$1140.67 \text{ k}$		769.77 <sup>16</sup> / <sub>12</sub>

$$e = \frac{769.77 \text{ k}}{1140.67 \text{ k}} = .67' \text{ from center - basically in center of slab area}$$

$$F.S. = W_s + W_c / U - W_g \quad \text{EM 1110-2-3104 Appendix B}$$

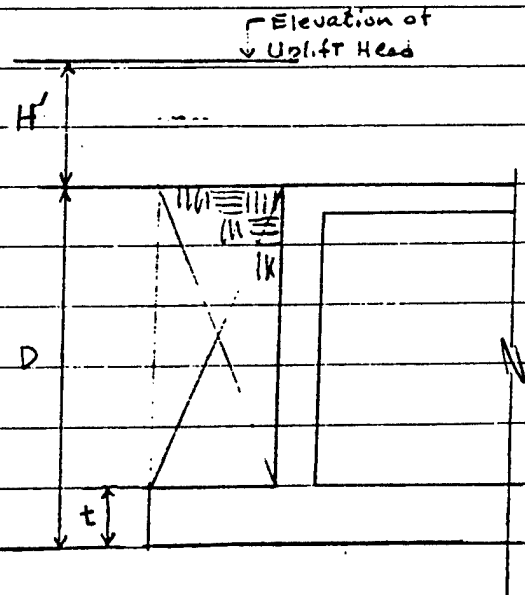
$$F.S. (\text{slotation}) = 1501.41 \text{ k} / 1140.67 \text{ k} = 1.32 < 1.5 \text{ req's slab extensions or thicker base slab.}$$

Slab extensions:

$$U - W_g = \gamma_w t = 62.5 t$$

$$W_s = \gamma_{\text{conc}} t + [(\gamma_{\text{sat}} - \gamma_w)(D - t) - (\gamma_w H')]$$

multiply  $(U - W_g)$  and  $W_s$  times the same Area.



NRA 1/4/91

✓ GRS 1/91

## Pumping Station

## Base Slab - Determine thickness

Assume rectangular soil pressure on base slab equal to total load  
(dead load + live load) divided by area of slab.

Total load is worst load on base slab during uplift or no uplift.

Live Load EM 1110-2-3104

$$\text{Roof: } (50 \text{ psf}) (27.33') (18.33') = 25.05$$

$$\text{Floor E1.714.75 (100 psf) (27.33') (18.33') = 50.10}$$

$$\text{Floor E1.710 (100 psf) (22') (16.67') = 36.67}$$

$$\text{Floor E1.693 (100 psf) (18') (31') = 55.80}$$

Floors misc items: trash can, cut walk, ladders, equip etc

$$(100 \text{ psf}) (18') (31') = 55.80$$

$$\text{Total Live Load} = 223.42^k$$

Soil load on 2' base slab extensions (previous sheet dead load):

$$(2' \times 115') \{ (708-695) [22' + 11' (2)] + (713-693) (26') \} + \{ (708-693) + (713-693) \} \left( \frac{1}{2} \right) (26') (2) \} = 460.46^k$$

concl. slab extensions:

$$(150 \text{ psf}) (3' \times 2') [22' (2) + 39' (2)] = 109.80^k$$

TOTAL DEAD LOAD

$$= 1501.41^k$$

$$\text{TOTAL LOAD} = 2295.09^k$$

$$\text{Soil Pressure} = 2295.09 / (26') (39') = 2.26 \text{ ksf}$$

## Pumping Station

✓ GRS 1/91

Flotation - 3' thick slab + 3' slab extensions Preliminary

$$U-W_g = (.0625 \text{ kcf})(3')(3')[(22')(2) + (41')(2)] = 70.88^k \uparrow$$

$$W_s = (.150 \text{ kcf})(3')(3')[(22')(2) + (41')(2)] \text{ concrete} = 170.10$$

$$W_s = [(.120 - .0625)(708 - 695) - (.0625)(713 - 708)](3')[(22' + 41')(2)]$$

$$+ [(.120 - .0625)(713 - 693) - (.0625)(716 - 713)](3')(28')$$

$$+ [(.120 - .0625)(708 - 693) - (.0625)(713 - 708)] + [(.120 - .0625)(713 - 693) - (.0625)(716 - 713)]$$

$$(\frac{1}{2})(3')(29')(2) \text{ Soil} = 272.47$$

$$W_s = 442.57^k \downarrow$$

$$F.S. = 1501.41 + 442.57 / 1140.67 + 70.88 = 1.60$$

Flotation - 3' thick slab + 2' slab extensions Preliminary

$$U-W_g = (.0625 \text{ kcf})(3')(2')[(22')(2) + (39')(2)] = 45.75^k \uparrow$$

$$W_s = (.150 \text{ kcf})(3')(2')[(22')(2) + (39')(2)] \text{ concrete} = 109.80$$

$$W_s = [(.120 - .0625)(708 - 695) - (.0625)(713 - 708)](2')[(22' + 41')(2)]$$

$$+ [(.120 - .0625)(713 - 693) - (.0625)(716 - 713)](2')(26')$$

$$+ [(.120 - .0625)(708 - 693) - (.0625)(713 - 708)] + [(.120 - .0625)(713 - 693) - (.0625)(716 - 713)]$$

$$(\frac{1}{2})(2')(26')(2) \text{ Soil} = 166.98$$

$$W_s = 276.78$$

$$F.S. = 1501.41 + 276.78 / 1140.67 + 45.75 = 1.50 \sim 1.50 (\text{OK})$$

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✓ GRS 1/91

## Pumping Station

Flotation with 2'-6" Base Slab

.5 less uplift head

$$1140.67^k - (6.5')(0.0625)(22')(35') = 1116.61^k$$

2.5' thick Base Slab

$$1501.41 - (6.5')(1.50)(22')(35') = 1443.66^k$$

Try 2'-3" base slab extensions

$$U-W_q = (.0625 kcf)(2.5')(2.25)[(22.5 + 39.5)(2)] = 43.59^k \uparrow$$

$$W_s(\text{concrete}) = (150 kcf)(2.5')(2.25)[(22.5 + 39.5)(2)] = 104.63$$

$$W_s(\text{soil}) (\text{see previous sheet}) 43.55 + 57.39 + 88.48 = 189.42$$

$$294.05^k \downarrow$$

$$F.S. = 1443.66 + 294.05 / 1116.61 + 43.59 = 1.50 \text{ (OK) Flotation Pump Station per}$$

EM 1110-2-3104

Volume of concrete in slab

Reinforcement of slab

Cost

2'-6" slab = 2589 c.f. @ 100/cy.

1.6 in<sup>2</sup>/ft 5<sup>8</sup>.20/lb

\$ 22,893

3'-0" slab = 3042 c.f. @ 100/cy.

1.2 in<sup>2</sup>/ft 3<sup>8</sup>.20/lb

\$ 24,417

→ USE 2'-6" Base Slab w/ 2'-3" extensions out from wall

## Pumping Station

## Base Slab (cont.)

Span 18' wall to wall. Moment at wall will be whatever moment is from wall. Therefore assume little fixity from wall.

Use hinge at wall or design base slab as simple supports betw. walls.

$$W = 2.29 \text{ K/FT} - (546 \text{ wt.}) (15)(3') = 2.29 - .45 = 1.84 \text{ K/FT.}$$

$$M = \frac{1}{8} w l^2 = \left(\frac{1}{8}\right) (1.84) (18)^2 = 74.7 \text{ K} = 896 \text{ K-in.}$$

$$M_u = 1.7 \times 1.3 \times 896 = 1980 \text{ K-in.}$$

$$d = 36 - 3.5 = 32.5$$

$$\phi M_n = .36 b d^2 = (.36)(12)(32.5)^2 = 4848 \text{ K-in.} > 1980 \text{ K-in. (ok)}$$

$$\phi M_n = \phi f_y A_s \left(d - \frac{A_s f_y}{170 b}\right) = 54 A_s (d - .74 A_s) = 2113 \text{ K-in. for } A_s = 1.2 \text{ IN}^2/\text{FT}$$

Try 2'6" thick Base Slab

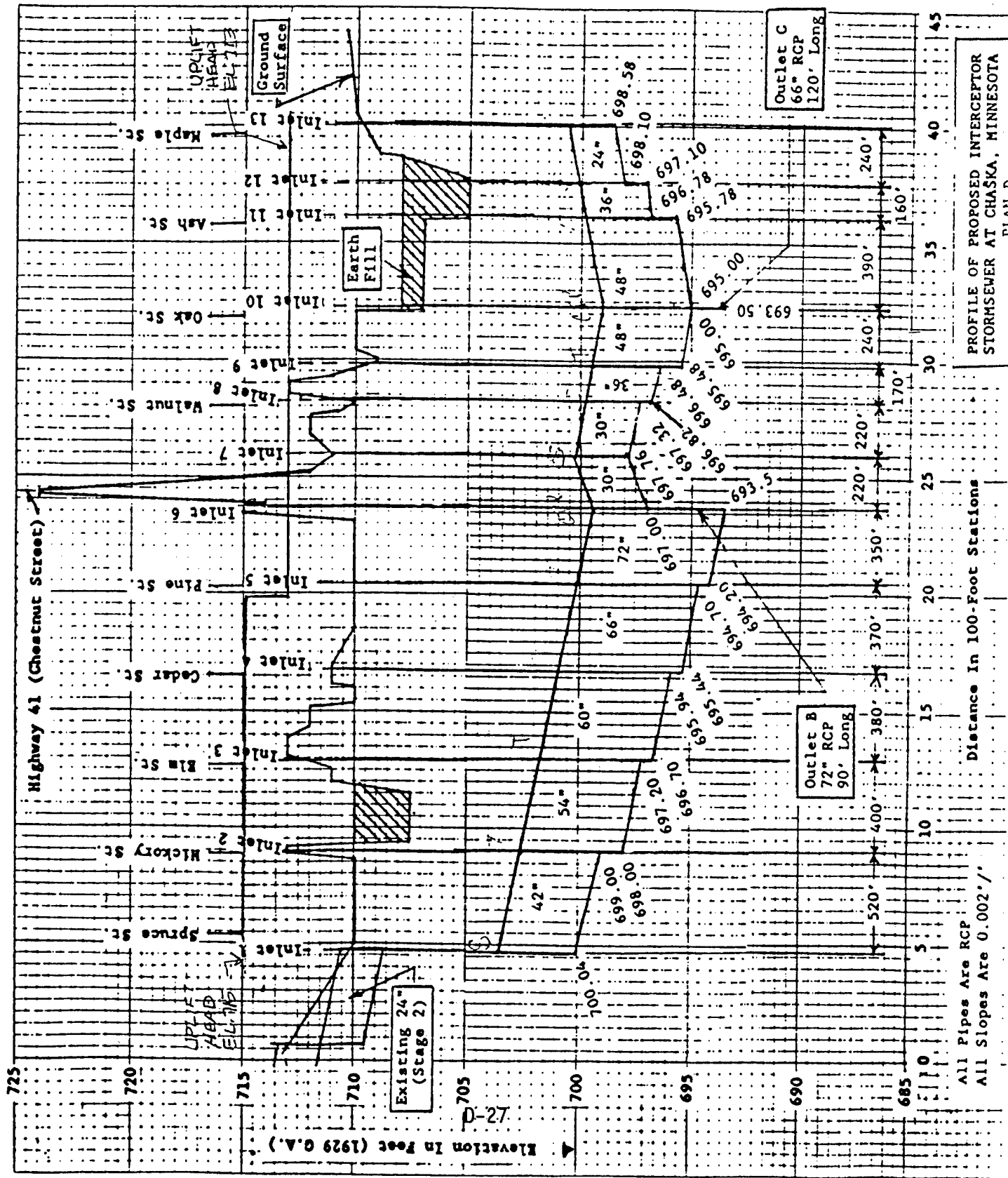
$$d = 30 - 3.5 = 26.5$$

$$\phi M_n = .36 b d^2 = (.36)(12)(26.5)^2 = 3033 \text{ K-in.} > 1980 \text{ K-in. (ok)}$$

$$\text{Max } A_s = 1007126 b h = (1007126)(12)(30) = 2.57 \text{ IN}^2/\text{FT.}$$

$$\phi M_n = 54 A_s (d - .74 A_s) = 2187 \text{ K-in. for } A_s = 1.6 \text{ IN}^2/\text{FT.}$$

Relief map  
1912 S-13



Rcd  
12/7/70

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TABLE A-20

## REQUIRED SIZE OF GRATED INLETS AND CONNECTING FEEDER PIPE

REQUIRED SIZE OF GRATES				REQUIRED SIZE AND LEVEL OF FEEDER PIPES									
Inlet Contrib. Location	Design 1% SPS	Approx. Max. Rim Elev.	Max. Allow. Pond Level (SPS)	Based On A Single Inlet (6)				Available Head In Feet (7)		Based on One Inlet		Based on Two Inlets	
				Reqd. Area (A)	Perm. Area (A)	Reqd. Area (A)	2A	Head In Feet (7)	RCP Pipe Size (Inches) (8)	Max. Allow. Invert Elev. (Inches) (9)	RCP Pipe Size (Inches) (8)	Max. Allow. Invert Elev. (Inches) (9)	Max. Allow. Invert Elev. (Inches) (9)
				(1)	(2)	(3)	(4)						
1 2a	37	57	710	2.9	3.8	7.0	13.9	0.11	-	-	48	2.4	708.5
2 2b	24	36	710	0.9	14.1	7.9	15.8	2.70	30	3.9	24	2.7	708.2
3 2c	23	34	710	0.9	13.3	7.4	14.9	4.38	24	6.0	24	2.6	708.3
4 2d	31	45	710	0.9	17.6	9.9	19.7	6.21	24	9.4	24	3.4	707.5
5 2e	27	40	710	0.9	15.6	8.8	17.5	8.31	24	7.6	24	3.0	707.9
6 2f	20	28	714	1.0	9.3	5.8	11.6	10.38	24	3.5	24	2.2	708.7
7 3a	29	42	711	1.5	7.6	7.1	14.2	1.72	36	3.5	24	3.2	709.3
8 3b	14	17	710	2.5	1.4	2.2	4.5	5.76	24	2.6	-	-	8
9 3c	17	31	709	3.5	1.6	3.4	6.9	8.60	24	5.3	24	2.3	710.2
10 3d	51	65	708	4.5	2.3	6.4	12.7	10.65	36	5.6	24	5.6	706.9
11 3e	34	47	708	4.5	1.6	4.6	9.2	7.34	24	9.8	24	3.6	708.9
12 3f	16	27	708	4.5	0.9	2.6	5.3	5.20	24	4.3	-	-	12
13 3g	21	25	709	3.5	1.3	2.8	5.6	0.62	36	2.6	24	2.0	710.5

2-24"φ

(1) Allowable pond level, less rim elevation.

(2) Ground level in area will permit this condition.

(3)  $Q = 3.12A^{1.5}$ ,  $L = Q/(3.12A^{1.5})$ (4)  $Q = 0.6A^{0.5}(2G^2H)^{0.5}$ ,  $A = Q/((0.6)(2G^2H)^{0.5})$ 

(5) Assumes grate is 50 percent obstructed.

(6) With two inlets, the indicated requirements can be reduced 50 percent.

(7) Maximum allowable pond level (SPS), less resulting hyd gradient for SPS from Table A-18.

(8) Assumes a pipe length of 20 feet.

(9) Maximum allowable pond level, less MW.

Use jacket valves on inlet.

R-1192

16" x 12" inlet manhole

16" x 12" inlet manhole

Largest Reg'd. Inlet Area is Inlet 4 @ 9.9 sq. ft.

Determine inlet size with reg'd area.

Try Neenah R-3246-Al Curb Inlet Frame, Grate, Curb Box (Cast Iron)

FOR TYPE L GRATE, FREE OPEN AREA = 3.0 SQ. FT. PER UNIT

multiple inlets are made from basic pattern with base flanges at butting sides eliminated.

Assume 1 inlet each side of street.

REF: TM 5-820-4/AFM 88-5, Chap. 4 3-10

For a combination inlet: In estimating capacity, the inlet will be treated as a simple grates inlet, but a safety factor of 25 to 75 percent will be applied. For a grates inlet use a safety factor of 100%.

∴ Area reg'd for inlet =  $1.75 \times 9.9 \text{ sq. ft.} = 17.3 \text{ sq. ft.}$

2 inlets with 3 units <sup>each</sup> =  $2 \times 3 \times 3.0^{\text{ft.}} = 18.0 \text{ sq. ft.}$  Area provided (F.S. = 1.02)

	Area Provided (sq. ft.) Gross opening 30" x 36"	Area (sq. ft.) A/1.75	Inlet No.
Combination curb-grate inlet			
2 inlets - 3 units each	18.0	10.3	1, 2, 3, 4, 5, 7
2 inlets - 2 units ea.	12.0	6.8	6, 10, 11
2 inlets - 1 unit ea.	6.0	3.4	8, 9, 12, 13

	Gross opening 30" x 36"	A/2.0	
Grated inlet			
2 inlets - 3 units + 4 units	21.0	10.5	4
2 inlets - 3 units ea.	18.0	9.0	1, 2, 3, 5, 7, 10
2 inlets - 2 units ea.	12.0	6.0	6, 9, 11
2 inlets - 1 unit ea.	6.0	3.0	8, 12, 13

→ Will not use curb inlets



# Chaska Stage 4 FDM

## Inlets

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✓ GRS 1/91

Determine inlet size with req'd. area.

Try Neenah R-4990 or R-4999 Heavy Duty Transverse Drainage Struct.

TYPE A GRATE (use because less wt. than type C with about same open sq. ft.)

R-4990-MX TYPE A (36" wide) = 1.3 sq. ft. open / l.f. ; R-4990-0X TYPE A (48" wide) = 1.7 sq. ft. open / l.f.

	Area Provided (sq. ft.)	Req'd Area sq. ft. $A / 2.0 \text{ (F.S.)}$	Inlet No.
<u>48" wide = 1.7 sq. ft. / l.f.</u>			
12' long	20.4	10.2	4, 5
10' long	17.0	8.5	2, 3, 7
8' long	13.6	6.8	6, 10
6' long	10.2	5.1	11
<sup>43" x 4"</sup> R-265-A 7.04 ft. 4' long	6.8	3.4	8, 9, 12, 13
16' long	27.2	12.5	1

36" wide = 1.3 sq. ft. / l.f.

→ 16' long	20.8	10.4	4
14' long	18.2	9.1	2, 5
→ 12' long	15.6	7.8	1, 3, 7
10' long	13.0	6.5	6, 10
8' long	10.4	5.2	11
→ 6' long	7.8	3.9	8, 9, 12, 13

$$\text{WT. 48" wide : } (2 \times 12') + (4 \times 10') + (2 \times 8') + (1 \times 6') + (4 \times 4') = 102 \text{ L.F.} \times (190 + 17) \% \text{ L.F.} = 21,114^{\#}$$

$$\text{WT. 36" wide : } (1 \times 16') + (2 \times 14') + (3 \times 12') + (2 \times 10') + (1 \times 8') + (4 \times 6') = 132 \text{ L.F.} \times (130 + 17) \% \text{ L.F.} = 19,404^{\#}$$

$$\text{Double inlets 48" wide : } (12 \times 6') + (10 \times 4') = 112 \text{ L.F.} \times 207 \% \text{ L.F.} = 23,184^{\#}$$

$$\text{Double inlets 36" wide : } (6 \times 8') + (14 \times 6') + (2 \times 4') = 140 \text{ L.F.} \times 147 \% \text{ L.F.} = 20,580^{\#}$$

Neenah type cast iron grates were used because they are commonly used in the industry for municipal<sup>D-20</sup> storm drain systems. They are corrosion resistant, strong enough for vehicle traffic, and heavy enough so they

NRH 12/5/90

✓ GRS 1/91

## Inlets

Determine least costly effluent inlets

Assume inlet 5' deep - 10" thick walls - 12" thick base

48" wide inlet - double inlet

$$6' \text{ long} - 12 (1 \times 6 \times 4) + (.83 \times 5 \times (6+4)(2)) = 1288$$

$$4' \text{ long} - 10 (1 \times 4 \times 4) + (.83 \times 5 \times (4+4)(2)) = 827$$

$$2115 \text{ c.f.} = 78.3 \text{ c.y.}$$

36" wide inlet - double inlet

$$8' \text{ long} - 6 (1 \times 8 \times 3) + (.83 \times 5 \times (8+3)(2)) = 692$$

$$6' \text{ long} - 4 (1 \times 6 \times 3) + (.83 \times 5 \times (6+3)(2)) = 1298$$

$$4' \text{ long} - 2 (1 \times 4 \times 3) + (.83 \times 5 \times (4+3)(2)) = 140$$

$$2130 \text{ c.f.} = 78.9 \text{ c.y.}$$

48" wide inlet - single inlets

$$12' \text{ long} - 2 (1 \times 12 \times 4) + (.83 \times 5 \times (12+4)(2)) = 362$$

$$10' \text{ long} - 4 (1 \times 10 \times 4) + (.83 \times 5 \times (10+4)(2)) = 625$$

$$8' \text{ long} - 2 (1 \times 8 \times 4) + (.83 \times 5 \times (8+4)(2)) = 263$$

$$6' \text{ long} - 1 (1 \times 6 \times 4) + (.83 \times 5 \times (6+4)(2)) = 107$$

$$4' \text{ long} - 4 (1 \times 4 \times 4) + (.83 \times 5 \times (4+4)(2)) = 330$$

$$1686 \text{ c.f.} = 62.5 \text{ c.y.}$$

36" wide inlet - single inlet

$$16' \text{ long} - 1 (1 \times 16 \times 3) + (.83 \times 5 \times (16+3)(2)) = 206$$

$$14' \text{ long} - 2 (1 \times 14 \times 3) + (.83 \times 5 \times (14+3)(2)) = 346$$

$$12' \text{ long} - 3 (1 \times 12 \times 3) + (.83 \times 5 \times (12+3)(2)) = 482$$

$$10' \text{ long} - 2 (1 \times 10 \times 3) + (.83 \times 5 \times (10+3)(2)) = 276$$

$$8' \text{ long} - 1 (1 \times 8 \times 3) + (.83 \times 5 \times (8+3)(2)) = 115$$

$$6' \text{ long} - 4 (1 \times 6 \times 3) + (.83 \times 5 \times (6+3)(2)) = 371$$

$$1815 \text{ c.f.} = 67.2 \text{ c.y.}$$

NR11 12/5/90

✓ GRS 1/91

## Inlets

Cost comparison between 48" + 36" wide inlets

single inlets

48" wide:

$$\text{Casting: } 102 \text{ L.F.} \times \$119/\text{L.F.} = 12,138$$

$$\text{Concrete: } 62.5 \text{ C.Y.} \times \$250/\text{C.Y.} = 15,625$$

$$\$27,763 \leftarrow \$2105 \text{ less}$$

36" wide:

$$\text{Casting: } 132 \text{ L.F.} \times \$99/\text{L.F.} = 13,068$$

$$\text{Concrete: } 67.2 \text{ C.Y.} \times \$250/\text{C.Y.} = 16,800$$

$$\$29,868$$

double inlets

48" wide -

$$\text{Casting: } 112 \text{ L.F.} \times \$119/\text{L.F.} = 13,328$$

$$\text{Concrete: } 78.3 \text{ C.Y.} \times \$250/\text{C.Y.} = 19,575$$

$$\$32,903 \leftarrow \$682 \text{ less}$$

36" wide -

$$\text{Casting: } 140 \text{ L.F.} \times \$99/\text{L.F.} = 13,860$$

$$\text{Concrete: } 78.9 \text{ L.F.} \times \$250/\text{C.Y.} = 19,725$$

$$\$33,585$$

For single or large inlets, based on the above analysis - use 48" wide  
36" or 48"

For double or smaller inlets, based on the small savings - either could be used.

Chaska Stage 4 FDM

NRH 12-5-90

Inlets

✓ GRS 1/91

Refer to Memo from Hydraulics 10 Sept. 90 Table A-20.

J. Megge gave me pipe sizes from inlets to M.H. (guess)

If feeder pipes are greater than 24" dia. the risers coming up from the interceptor must be greater than 48" dia. Because the interceptor is so deep, it is assumed the risers will be no greater than 48" due to more cost of larger riser pipe.

Therefore any pipe between the inlet and M.H. must be 24" dia or less.

So if a pipe size greater than 24" is required, then use 2 inlets so pipe is less than 24".

Flootation of Inlets

<u>Inlet or M.H. No.</u>	<u>Uplift Head Elevation</u>	<u>Inlet Rim Elevation</u>
1	715	710
2	715	710
3	715	710
4	715	710
5	713	710
6	713	714
7	713	711
8	713	710
9	713	709
10	713	708
11	713	708
12	713	708
13	713	709
14	713	710

Inlets and feeder pipes will have 2' of pervious fill all around and a deep layer of graded gravel with the same area as the inlet opening at inlets.

By using this fill plan the inlets and feeder pipes will not have uplift forces on them above grate elev.

MANHOLE	No. of INLETS	Size of INLET
---------	------------------	------------------

1	1	4'x16'
2	2	4'x6'
3	1	4'x10'
4	1	4'x12'
5	1	4'x12'
6	1	4'x8'
7	2	4'x6'
8	1	4'x4'
9	1	4'x4'
10	2	4'x4'
11	1	4'x6'
12	1	4'x4'
13	2	4'x4'

Table based on 24"  $\phi$  R.C.P. feeder pipes.

into 48"  $\phi$  M.H. riser. pipes must be  
greater than 104" apart.

# Inlets

✓ GRS 1/91

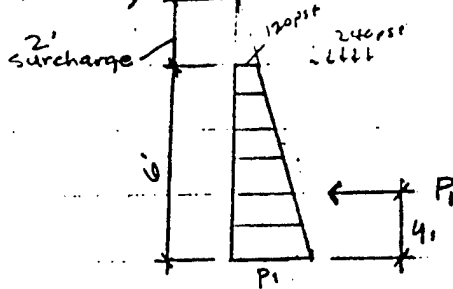
Assume deepest inlet 6'-0" deep

Design for worst of two conditions:

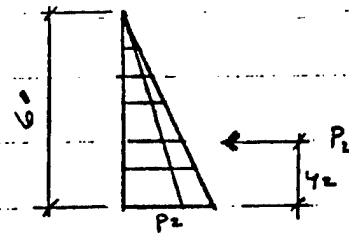
1. moist soil + 2' surcharge
2. water table to grating El.

Lateral Pressure: Pervious material

$\phi = 30^\circ$ , AT REST  $K_o = 1 - \sin 30^\circ = .5$ ,  $\gamma_{\text{moist}} = 120 \text{ pcf}$ ,  $\gamma_{\text{sat}} = 125 \text{ pcf}$



Condition 1



Condition 2

$$P_1 = K_o \gamma_{\text{moist}} H = (.5)(120)(8') = 480 \text{ KSF}$$

$$= 480 \text{ KSF} \cdot .120 = 360$$

$$P_2 = K_o \gamma_{\text{sub}} H + \gamma_{\text{water}} H$$

$$= [.5(125 - 62.5) + (62.5)](6) = .563 \text{ KSF}$$

$$P_{1A} = (120)(6) = .720 \text{ K}, y = \frac{6}{2} = 3'$$

$$P_2 = (.563)(6)/2 = 1.69 \text{ K}, y = \frac{6}{3} = 2'$$

$$P_{1B} = \left(\frac{360}{2}\right)(6) = 1.08 \text{ K}, y = \frac{1}{3}(6) = 2'$$

$$M_1 = (.72)(3) + (1.08)(2) = 2.16 \text{ K} = 26 \text{ in-K}$$

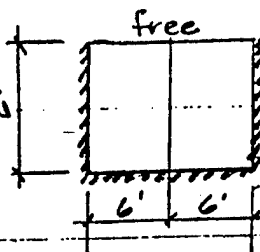
$$M_2 = (1.69)(2) = 3.375 \text{ K} = 40.5 \text{ in-K} \leftarrow \text{worst}$$

Determine wall thickness.

Condition 2 controls - use this load, but moment can be reduced by using box shape. Largest inlet 12' long.

Use Monograph of tables used for rectangular plates + slab - moment + shear coeff.

Fixed on 3 sides.  $a/b = 6/6 = 1$



## Inlets

✓ GRS 1-91

Figure 4:  $R_y = .4584$



$$\text{Max. shear} = (.4584)(.563)(6) = 1.55^k$$

$$10'' \text{ thick walls min. } d = 10 - 2.5 = 7.5''$$

$$V_u = 1.7 \times 1.55 = 2.63^k$$

$$\checkmark \phi V_c = (.85)(126)(12)(7.5) = 9.64^k > 2.63^k$$

Figure 4:  $M_y = .0845$



$$\text{Max. Mom.} = (.0845)(.563)(6)^2 = 1.71^k = 21^k$$

$$M_u = 1.7 \times 21 = 35^k$$

$$p_{max} = .25 / 6 = .007126 \quad d = 7.5''$$

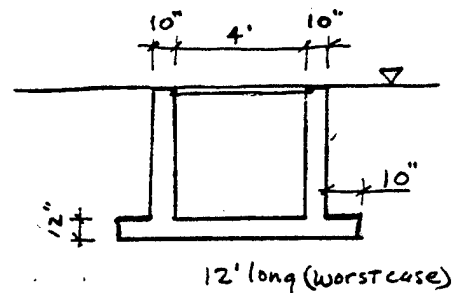
$$\checkmark \phi M_u = (.9)(60)(.007126) \left[ 1 - \frac{(.60)(.007126)}{(.7)(4)} \right] (12)(7.5)^2 = 4.33(7.5)^2 = 243^k > 35^k \text{ ok}$$

Flotation ETL 1110-2-307

$$U = (.0625)(7')(5.66')(13.67) = 33.89^k$$

$$W_s (\text{concrete}) = (.15)(1.0)(7.33)(15.33) + (.83)(6')(35.33) = 43.36^k$$

$$W_s (\text{grating}) = 19^k / 1 \times 12' = 2.28^k$$



TRY 10" slab extensions

$$U - W_g = (.0625)(1.0)(.83)(42') = 2.19^k$$

$$W_s (\text{concrete}) = (.15)(1.0)(.83)(42') = 5.25^k$$

$$W_s (\text{soil}) = (.120 - .0625)(42')(83) = 12.07^k$$

$$F.S. = W_s / (U - W_g) = 43.36 + 2.28 + 5.25 + 12.07 / 33.89 + 2.19 = 1.75 > 1.5 \text{ (ok)}$$

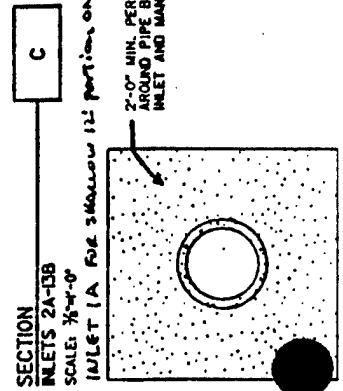
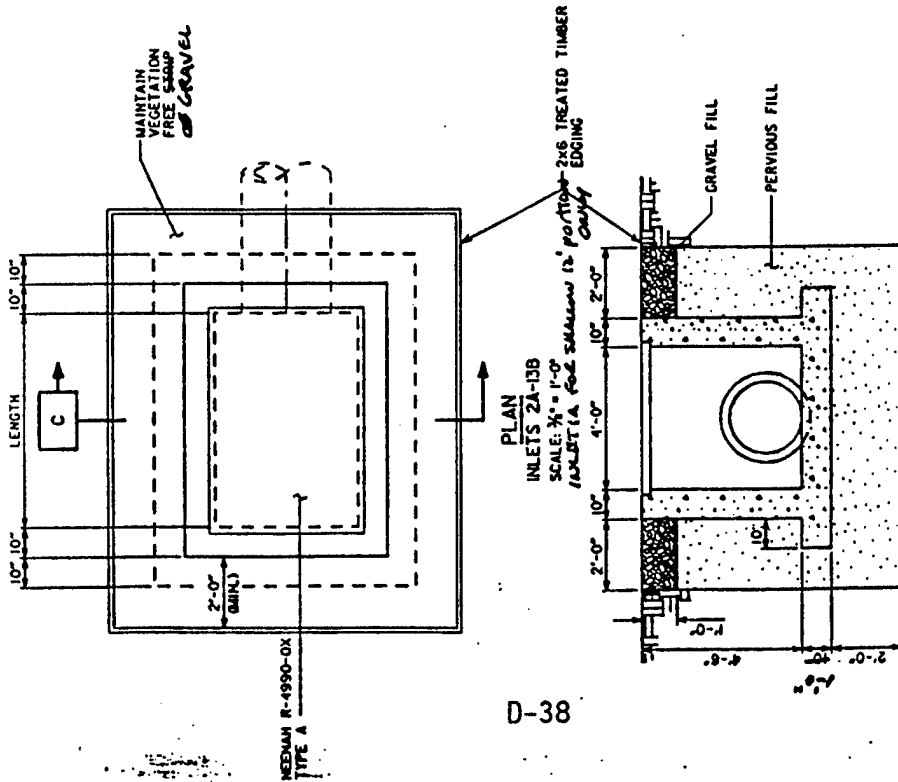
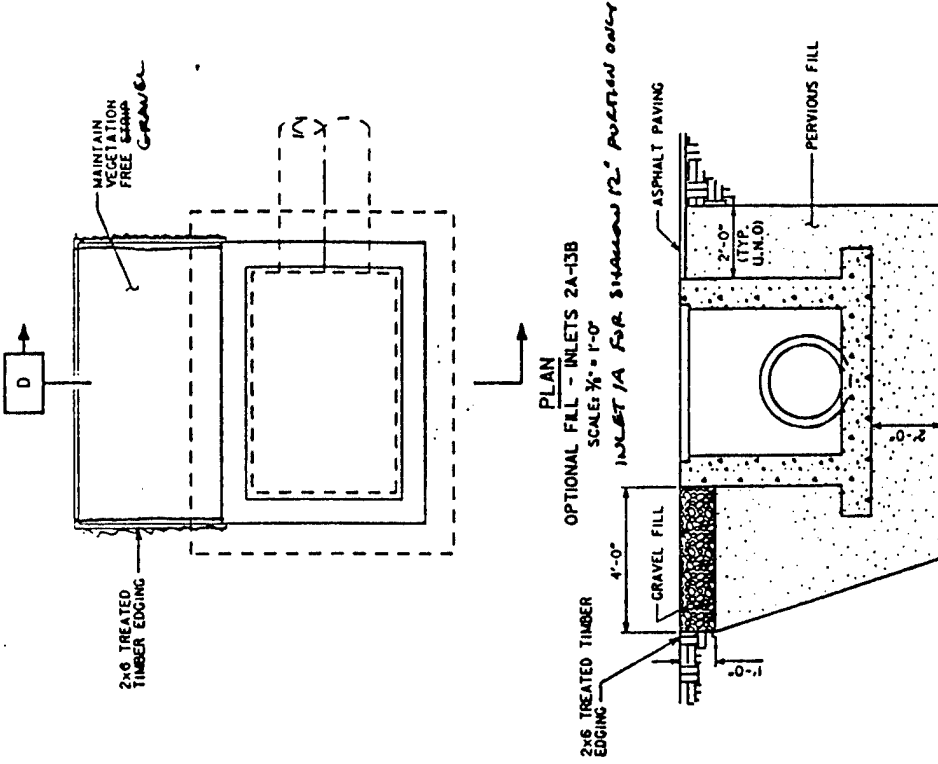
Use 12" slab so there will be two layers of reinforcing  
and one layer will extend <sup>D-37</sup> into 10" slab extensions



# INLET

page 31  
NRH 1-24-91

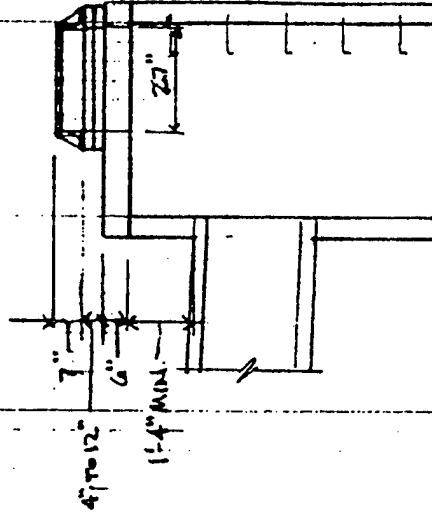
V GRS 1/91



NRH 12/20/90  
- GRS 1/91

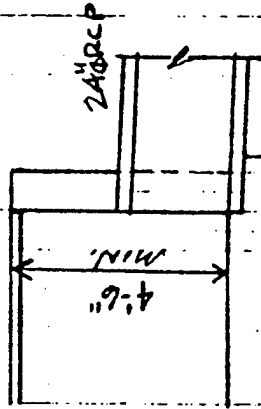
USE SAME NOTES AS  
CITY OF CHASKA  
STANDARD DETAIL PLATES  
STD-3

NEENAH  
R 1642



STORM SEWER MANHOLE  
WITH REINFORCED TOP SLAB

NEENAH  
R-4990-OX TYPE A



INLET

Determine D-load at 0.01-in. crack

Reference: American Concrete Pipe Assoc. Design Manual

Determine Pipe Class as specified in ASTM C76.

ASTM C76 class <u>Circular RCP</u>	D-load to produce <u>a 0.01-in. crack</u> (pounds/l.f. / ft. dia.)
---------------------------------------	---

I	800
II	1000
III	1350
IV	2000
V	3000

$$D\text{-load} = \left( \frac{W_L}{1.5} + \frac{W_E}{L_f} \right) \frac{F.S.}{D} \quad (\text{Equation 33a})$$

(Tables 13-42)

$W_E$  = Earth Load (increase backfill loads from tables by 20% for backfill weighing 120pcf)

$W_L$  = Live Load (Table 45)

$L_f$  = Load Factor (Figure 227)

$F.S.$  = Factor of Safety (page 42)

$D$  = pipe inside diameter

Trench condition

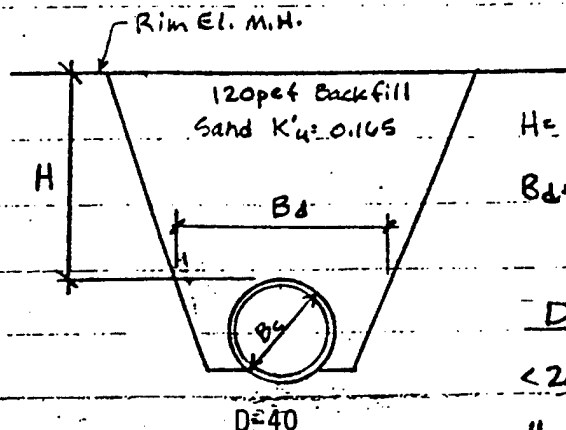
Ordinary Bedding

$L_f = 1.5$

Factor of Safety

$F.S. = 1.0$

$F.S. = 2.0$  (in levee)



$H$  = Height of fill above pipe

$B_d$  = trench width at top of pipe

$D$	Max. $B_d$
-----	------------

$< 20"$	$B_d + 12"$
---------	-------------

$20" - 48"$	$B_d + 24"$
-------------	-------------

$> 48"$	$B_d + 36"$
---------	-------------

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NRH 1-25-91

✓ GRS 1/91

Interceptor RCP - Worst case for each size

D (in.)	H (ft.)	B <sub>d</sub> (ft.)	WE (#/ft.)	WL (#/ft.)	D-load	ASTM C7 Class
24"	8.17'	4.50'	3317	270	1196	III
30"	14.21'	5.08'	4712	-	1256	III
36"	9.19'	5.67' arch	4840	290	1140	III
42"	7.13'	8'	5064	500	1060	III
48"	9.10'	6.83' arch	6034	380	1069	III
54"	7.84'	10'	4779	490	1077	III
60"	8.56'	9.00'	7931	515	1126	III
66"	9.26'	9.58'	9104	430	1156	III
72"	13.92'	10.17'	13410	-	1590	III
18"	9.21'	2.92'	2004	170	966	III
Feeder Pipes						
24" Relief well drain pipes	2' Worst case M.H. & C	4.50'	600	1780	794	II
12"	14.21'	2.33'	1430	-	960	II

- Use ASTM C76 Class III interceptor RCP for all sizes
- Use ASTM C76 Class II for feeder pipes betw.  
inlets and M.H.

Outlet Pipes (in levee)

✓ GRS 1/91

Determine D-load at 0.01-in. crack

Reference: American Concrete Pipe Assoc. Design Manual

EM 1110-2-2902 "Conduits, Culverts + Pipes"

Determine pipe Class as specified in ASTM C76 or ASTM C655

OUTLET		Inlet					
C	B	D (in)	H (ft.)	B <sub>d</sub> (ft.)	W <sub>e</sub> (#/ft.)	W <sub>L</sub> (#/ft.)	D-load
40'	40'	48	El. 725 37.5	8'	18,318	-	6106
60'	60'	48	El. 711.5 24	8'	14,628	-	4876
		48	El. 699.25 11.83'	8'	8985	-	2995
		48	El. 692. 4.5'	8'	2970	-	990
125'	130'						
35'		66	El. 724 30'	10'	22,848	-	5540
55'		66	El. 724 25'	10'	20,424	-	4950
35'		66	El. 712 12.5	10'	12,287	-	2980
120'							
40'		72	El. 729 29.5'	11'	25,836	-	5740
50'		72	El. 723.5 23.5'	11'	22,260	-	4950
90'							

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NRH 1-28-91

✓ GRS 1/91

Interceptor RCP

18" class III

24" class III

30" class III

36" class III

42" class III

48" class III

54" class III

60" class III

66" class III

72" class III

Feeder RCP from inlets to M.H.'s

24" class II

Relief well drain pipes

12" class II

Outlets

48" D-load 6000

48" D-load 5000

48" class II

72" D-load 6000

72" D-load 5000

66" D-load 6000

66" D-load 5000

66" class V

OUTLET B

80 L.F.

120 L.F.

60 L.F.

40 L.F.

50 L.F.

OUTLET C

80 L.F.

120 L.F.

50 L.F.

35 L.F.

55 L.F.

35 L.F.

Chaska Stage 4 EDM

NRH 12/11/90

✓ GRS 1/91

REFER: ETL 1110-2-307 Flotation Stability Criteria for Hydraulic Structures  
EM 1110-2-3104 Appendix B - struc + Arch Design of Pumping Stations.

## BOUOYANCY OF MANHOLES AND TEES

## Condition A:

- Uplift designed for uplift head at specific location.
- Soil saturated.
- water in pipe up to lowest operating range of pumps El. 698.
- F.S. = 1.5

## Condition B:

- Uplift designed for water table at El. 700.
- Pipe empty
- F.S. = 1.5

## Condition C:

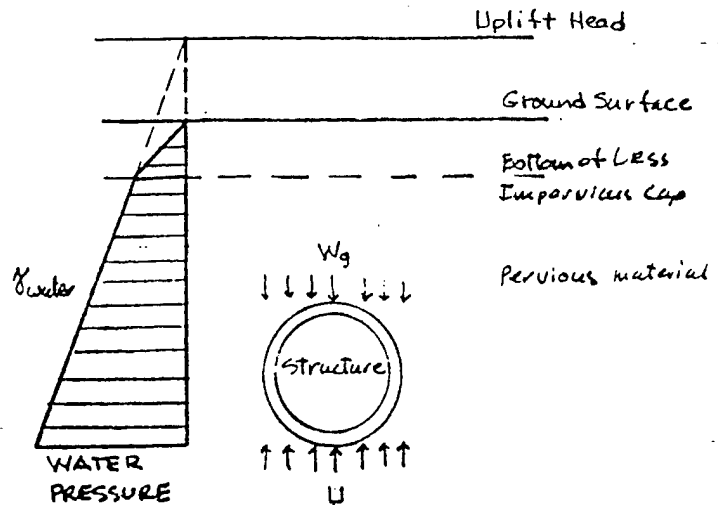
- Uplift designed for uplift head at specific location
- soil saturated
- water in pipe to lowest elev. pumps will pump to if malfunctioning. El. 695  
this could only occur between inlets 7 + 13. Inlets 1 thru 6 same as condition A.
- F.S. = 1.1

Flotation = Structures below ground water

$$F.S. = \frac{W_s + W_c + S}{W - W_g} \quad E.T.L. 1110-2-307$$

For definition of symbols  
see reference.

$(W - W_g)$  will be used in flotation calculations as the weight of water displaced by the volume of the submerged portion of the structure.



CONDITION WITH UPLIFT  
HEAD ABOVE GROUND SURFACE

The submerged weight of soil above the structure will be decreased because of the head that must be dissipated in the top layer of less impervious material. The decrease in the weight will be the weight of water in the volume above the structure between the uplift head and the ground surface.  $W_s$  = submerged wt. of soil above the structure and the weight of the structure.

In this loading condition no surcharge load will be applied, since it would not be reasonable to have at the same time as highest river event and most of the structures are deep enough so surcharge would not be felt.

The above is Normal Operation and should have min  $S.F. = 1.5$



Flotation -

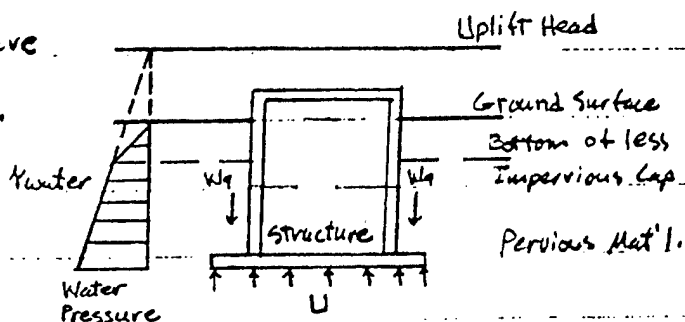
✓ GRS 1/91

$$F.S. = \frac{W_s + W_c + S}{U - W_q}$$

ETL 1110-2-307 see for definitions of symbols.

$U$  will be the water pressure  
up at the bottom of the structure  
using the Uplift Head Elevation.

$W_q$  Will be the water pressure  
down on any part of the  
structure below the  
ground surface using the  
Uplift Head Elevation.



CONDITION WITH UPLIFT HEAD ABOVE  
GROUND SURFACE

The submerged weight of soil will be calculated the same as described  
for submerged structures.

Surcharge explanation is same as described for submerged structures.

The above is Normal Operation and has min.  $SF_4 = 1.5$ .

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NRH 1-16-91

✓ GRS 1/91

Flotation

M.H. 3 - 60" Interceptor

$$O.D. = 6" + 60" + 6" = 72" = 6.0'$$

Inv. El. = 696.70 , Rim. El. 710 , & El. of pipe = 699.20

Condition A: Uplift Head El. 715

Flotation of 60" Interceptor:

$$U - W_g = (.0625 \times \frac{\pi}{4}) (6.0)^2$$

$$= 1.77 \text{ k/L.F.} \uparrow 1.44$$

$W_s(60" \text{ pipe})$

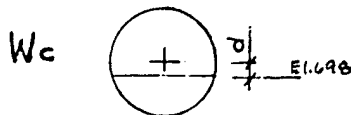
$$= 1.325 \text{ k/L.F.} \downarrow 1.095$$

$$W_s(\text{soil}) = (.120 - .0625) [(710 - 699.20)(6.0) - (\frac{\pi}{8})(6)^2]$$

$$- [(0.0625)(715 - 710)(6)] = 2.91 - 1.88$$

$$= 1.04 \text{ k/L.F.}$$

$$W_s = 2.36 \text{ k/L.F.} \downarrow 1.10$$



$$R = 2.5', d = 699.2 - 698 = 1.2'$$

$$= [(2.5)^2 \cos^{-1}(\frac{1.2}{2.5}) - 1.2 \sqrt{(2.5)^2 - (1.2)^2}] (.0625) = 0.25 \text{ k/L.F.} \downarrow .12$$

$$F.S. = W_s + W_c / U - W_g = 2.36 + .25 / 1.77 = 1.48 \sim 1.5 \text{ (OK)}$$

VGRS 1/91

## Flotation

Check flotation of 48"  $\phi$  riser M.H. 3

$$U = (.0625)(715 - 701.7)(\frac{\pi}{4})(4.83)^2 = (.0625)(13.30)(18.35)$$

$$U = 15.25^k$$

$W_s$  (pipe betw. Rim El. + top of Tee Section)

$$= (.885)(710 - 703.2) + 1.11 \text{ top} = 6.02 + 1.11$$

$$= 7.13$$

$$W_{s, \text{soil}} = - \left\{ (.0575)(710 - 701.7)(\frac{\pi}{4})(4.83)^2 \right\}$$

$$- \left\{ (.0625)(715 - 710)(\frac{\pi}{4})(4.83)^2 \right\} = -(8.76 - 5.73)$$

$$= -3.02$$

$$W_s = 4.11$$

## Flotation of Tee

$U$  (riser)

$$= 15.25$$

$$U - W_q \text{ (interceptor)} = 1.77 \times 12'$$

$$= 21.24$$

$$\text{Total } U - W_q = 36.49$$

$W_s$  (riser)

$$= 4.11$$

$$W_s \text{ (interceptor)} 2.36 \times 12$$

$$= 28.32$$

$$\text{Total } W_s = 32.43$$

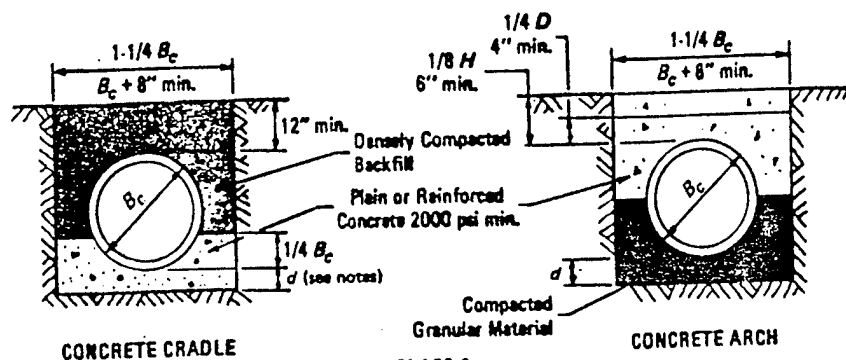
$$W_c \text{ (interceptor)} .25 \times 12'$$

$$\text{Total } W_c = 3.00$$

$$F.S. = W_s + W_c / U - W_q = 32.43 + 3.00 / 36.49 = 0.97 < 1.5 \text{ N.G.}$$

Refer to Concrete Pipe Handbook -

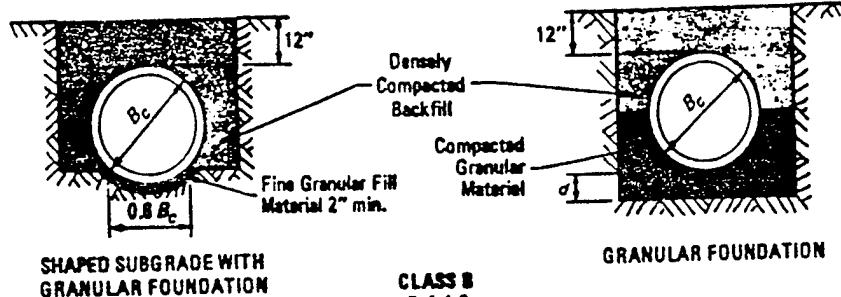
Use Concrete Arch for weight. If the concrete cradle were used, metal straps would be required to tie pipe down to slab. There would be a possibility the tie downs would corrode. The concrete Arch cannot fail and works on gravity alone.



CONCRETE CRADLE

CONCRETE ARCH

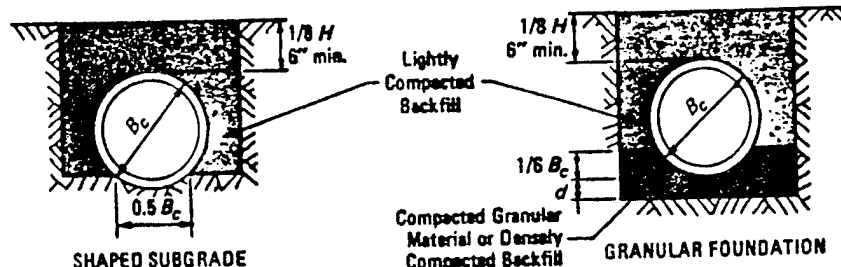
## CLASS A

Reinforced  $A_s = 1.0\% B_f = 4.8$ Reinforced  $A_s = 0.4\% B_f = 3.4$ Plain  $B_f = 2.8$ 

SHAPED SUBGRADE WITH GRANULAR FOUNDATION

GRANULAR FOUNDATION

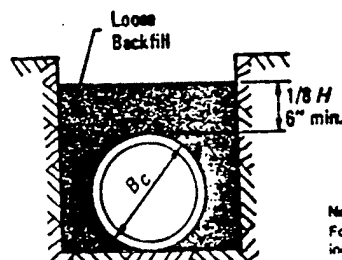
## CLASS B

 $B_f = 1.9$ 

SHAPED SUBGRADE

GRANULAR FOUNDATION

## CLASS C

 $B_f = 1.5$ 

FLAT SUBGRADE

## CLASS D

 $B_f = 1.1$ 

## Depth of Bedding Material Below Pipe

D	d (min.)
27" & smaller	3"
30" to 60"	4"
66" & larger	6"

## Notes:

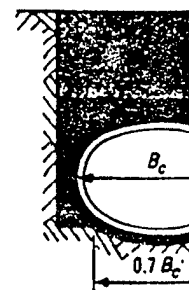
For Class A beddings, use  $d$  as depth of concrete below pipe unless otherwise indicated by soil or design conditions.

For Class B and C beddings, subgrades should be excavated or over excavated, if necessary, so a uniform foundation free of protruding rocks may be provided.

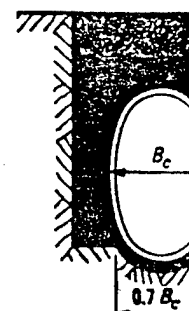
Special care may be necessary with Class A or other unyielding foundations to cushion pipe from shock when blasting can be anticipated in the area.

## Legend

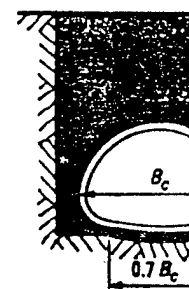
$B_c$  = outside diameter  
 $H$  = backfill cover above top of pipe  
 $D$  = inside diameter  
 $d$  = depth of bedding material below pipe  
 $A_s$  = area of transverse steel in the grade of arch expressed as a percentage of area of concrete at invert or crown.



## CLASS B

 $B_f = 1.9$ 

## CLASS B

 $B_f = 1.9$ 

## CLASS B

 $B_f = 1.9$ 

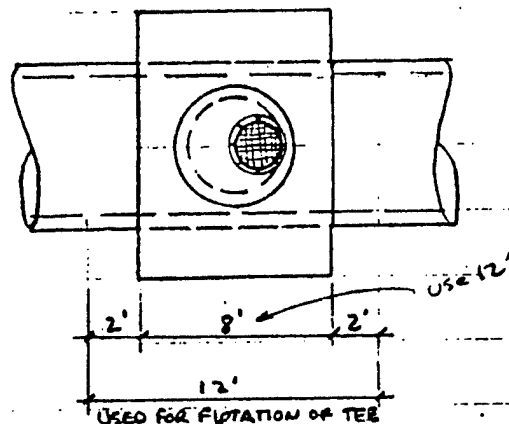
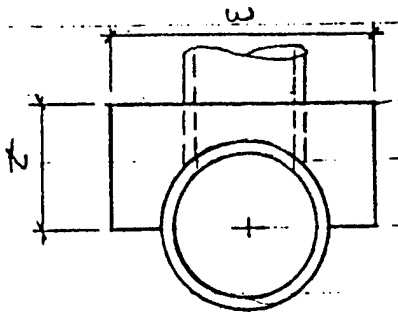
Figure 9.16. Trench Beddings, Circular Pipe.

Figur

# Flotation of Tee

M.H. 3

Determine size of concrete arch on tee to provide  
 $F.S. = 1.5$  for flotation.



For 60" pipe:

$$t = (\frac{1}{4})(60") + (\frac{1}{2})(72") = 4.25'$$

Try  $w = 13'$ ,  $h = 8'$  long

$U - W_g$  = density of water x volume of structure submerged

$$= (.0625) [(13)(4.25) + \frac{\pi}{4}(6)^2](8') = 34.70$$

$U$  = density of water x volume of riser to uplift head taken from inside crown of interceptor

$$= (.0625)(\frac{\pi}{4})(4.83)^2(715 - 701.7) = 15.25$$

$U - W_g$  = 2' of interceptor each side of tee

$$= (.0625)(\frac{\pi}{4})(6)^2(4') = 1.77 \text{ kl} \times 4' = 7.07$$

Total  $U - W_g$  = 57.02 kl

$$W_{s1} \text{ concrete arch} = (.150) [(13)(4.25) - \frac{\pi}{4}(6)^2](8') - [(\frac{\pi}{4})(4.83)^2(1.75)] = 44.52$$

$$W_{s2} \text{ 48" pipe + top + 60" pipe} = 6.02 + 1.11 + (1.325)(12') = 23.03$$

$W_{s3}$  = submerged wt. of soil above concrete arch minus density of water

x volume between uplift head and ground surface =  $[(.120 - .0625)$

$$(710 - 702.44) - (.0625)(715 - 710) [(13)(8') - \frac{\pi}{4}(4.83)^2] = 10.47$$

$W_{s4}$  = submerged wt. of soil above interceptor minus density of water

x volume between uplift head and ground surface for riser side of tee

$$= 1.04 \text{ kl} \times 4' = 4.16$$

# Flotation of Tee

M.H. 3

$$\text{Total } W_s = 82.17$$

$$W_c = \text{water to El. 698} = 0.25 \text{ kl.} \times 12' \quad \text{Total } W_c = 3.00$$

$$F.S. = \frac{W_s + W_c}{U - W_q} = \frac{82.17 + 3.00}{57.02} = 1.49 \sim 1.50 (\text{ok})$$

- Use 12' long concrete arch so joint at Tee section with

Try  $W = 10.5'$ , 12' long not be over deflected from extra wt. of concrete, - also less excavation -

$U - W_q$  = density water x volume of structure submerged

$$= (0.0625) \left[ (10.5') (4.25') + \left( \frac{\pi}{8} \right) (6')^2 (12') \right] = 44.07$$

$U$  = density water x volume of riser between uplift head + inside crown of interceptor

$$= (0.0625) \left( \frac{\pi}{4} \right) (4.83')^2 (715 - 701.7) = 15.25$$

$$\text{Total } U - W_q = 59.32$$

$$W_{s1} = \text{concrete arch} = (150) \left\{ (10.5') (4.25') - \left( \frac{\pi}{8} \right) (6')^2 (12') - \left[ \left( \frac{\pi}{4} \right) (4.83')^2 (1.75') \right] \right\} = 50.06$$

$$W_{s2} = 48" \text{ pipe } + \text{top } + 60" \text{ pipe} = 6.02 + 1.11 + 15.90 = 23.03$$

$W_{s3}$  = submerged wt. of soil above concrete arch minus density of water

x volume between uplift head and ground surface =  $[(1.120 - .0625)$

$$(710 - 702.44) - (.0625) (715 - 710) \left\{ (10.5') (12') - \left( \frac{\pi}{4} \right) (4.83')^2 \right\} = 13.25$$

$$\text{Total } W_s = 86.24$$

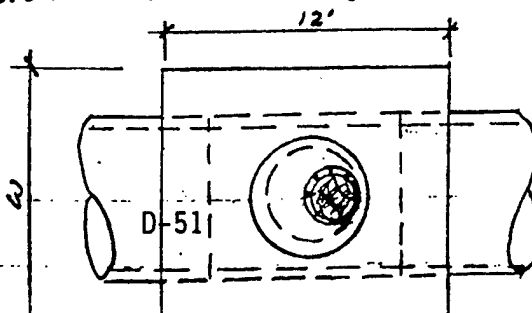
$$W_c = \text{water to El. 698} = .25 \text{ kl.} \times 12'$$

$$\text{Total } W_c = 3.00$$

$$F.S. = \frac{W_s + W_c}{U - W_q} = \frac{86.24 + 3}{59.32} = 1.50 = 1.50 (\text{OK})$$

→ M.H. 3 concrete arch

size 10'-6" W x 12'-0" L x 4'-3" H



✓GRS 1/91

# Flotation

M.H. 2 - 54" Interceptor dia. = 5'1/2 + 54 + 5'1/2 = 5'-5"

Inv. El. 698.0 , Rim El. 710 , Elev. of pipe 700.25

Condition A: Uplift Head El. 715

Check flotation of 54" Interceptor

$$U - W_g = (.0625) \left( \frac{\pi}{4} \right) (5.42')^2 = 1.44 \text{ k/L.F.}$$

$$\text{pipe} = 54" \text{ pipe} = 1.10$$

$$\begin{aligned} \text{soil} &= (.120 - .0625) \left[ (710 - 700.25)(5.42) - \frac{\pi}{8} (5.42)^2 \right] - (.0625)(715 - 710)(5.42) \\ &= (.0575) \left[ (9.75)(5.42) - (11.52) \right] - (.0625)(5)(5.42) = 2.37 - 1.69 = 0.68 \end{aligned}$$

$$W_s = 1.78 \text{ k/L.F.}$$

$$F.S. = \frac{W_s}{U - W_g} = \frac{1.78}{1.44} = 1.24 < 1.5 \text{ (N.G.)}$$

Check 54" Interceptor at M.H. 3

Inv. El. 697.20 , Rim El. 710 , Elev. of pipe 699.45

Condition A: Uplift Head El. 715

$$U - W_g = 1.44 \text{ k/L.F.}$$

$$W_{s, \text{pipe}} = 1.10$$

$$W_{s, \text{soil}} = (.0575) \left[ (710 - 699.45)(5.42) - \frac{\pi}{8} (5.42)^2 \right] - (.0625)(715 - 710)(5.42) = 0.93$$

$$W_s = 2.03 \text{ k/L.F.}$$

$$\begin{aligned} W_c &= \left[ (2.25)^2 \cos^2 \left( \frac{1.45}{2.25} \right) - 1.45 \sqrt{(2.25)^2 - (1.45)^2} \right] (.0625) W_c = 0.12 \text{ k/L.F.} \\ R &= 2.25', d = 699.45 - 698 = 1.45' \end{aligned}$$

$$F.S. = \frac{W_s + W_c}{U - W_g} = \frac{2.03 + 0.12}{1.44} = 1.49 \sim 1.50$$

∴ Concrete arch needed for wt. on 54" interceptor betw. M.H.s. 2 + 3.

## Flotation

VGRS 1/91

Determine size of concrete arch for 54" interceptor  
based on Elevations at M.H. 2. (see figure for 42")

for 54" pipe:  $t = \frac{54}{4} + \frac{65}{2} = 46" = 3.83'$

Try  $w = 7'-0"$

$$U-W_q = (.0625) \left[ (7') (3.83') + \left( \frac{\pi}{8} \right) (5.42')^2 \right]$$

$$U-W_q = 2.40 \text{ k/l.f.}$$

$$W_{s1} = \text{concrete arch} = (.150) \left[ (7') (3.83') - \left( \frac{\pi}{8} \right) (5.42')^2 \right]$$

$$= 2.29$$

$$W_{s2} = 54" \text{ pipe}$$

$$= 1.10$$

$$W_{s3} = \text{soil} = \left[ (.0575) (710 - 704.08) - (.0625) (615 - 710) \right] (7')$$

$$= 0.19$$

$$W_s = 3.58 \text{ k/l.f.}$$

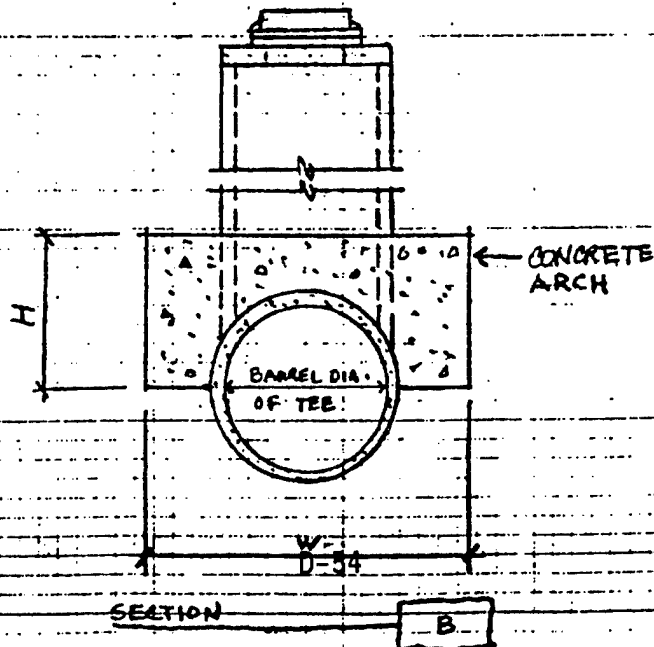
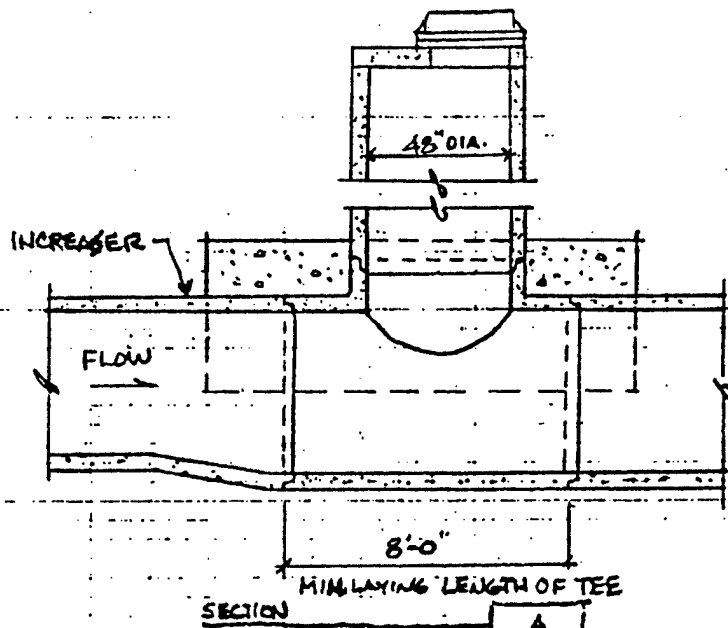
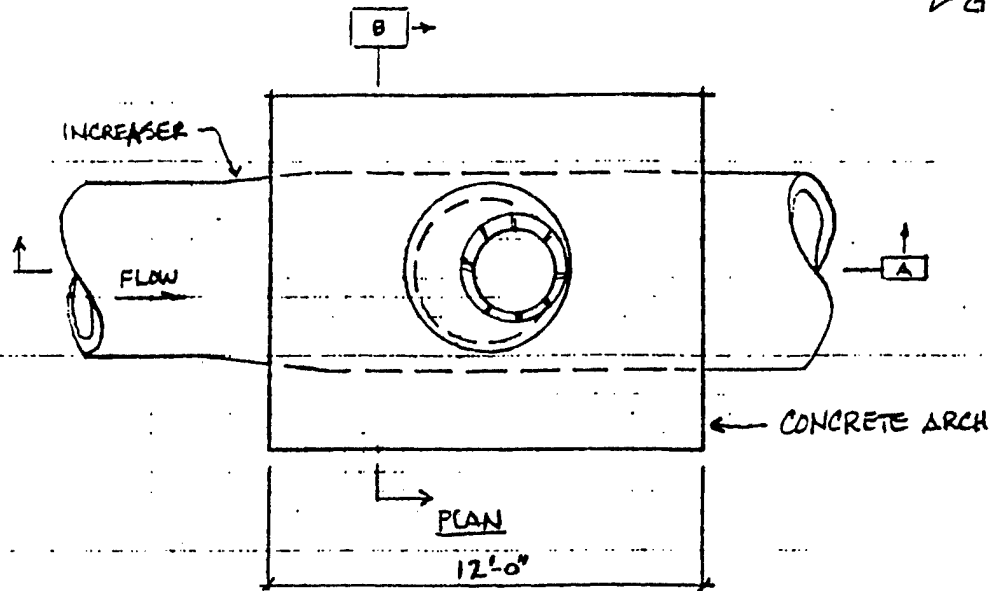
$$F.S. = \frac{W_s}{U-W_q} = \frac{3.58}{2.40} = 1.49 \sim 1.50 \text{ (ok)}$$

→ Between M.H. 2 and M.H. 3 use concrete arch over pipe  
size 7'-0" W x 3'-10" H



RCP TEES + CONCRETE ARCH

page 47  
NRH 1-24-91  
✓GRS 1/91

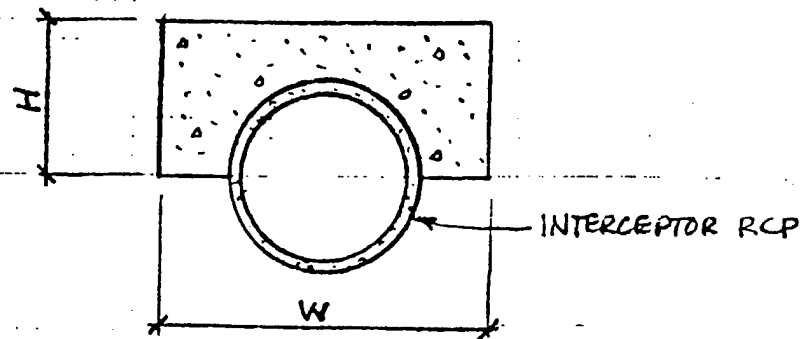


# RCP CONCRETE ARCH

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NRH 1-24-91

VGRS 1/91



## SECTION

INTERCEPTOR BETWEEN M.I.H.'S	W.	H.
1-2	6'-0"	3'-0"
2-3	7'-0"	3'-10"

## Floatation of M.H.

M.H. 13 - Straight M.H. w/ slab cover

Inv. El. = 698.58 - Rim El. = 709.0

Check floatation of M.H.

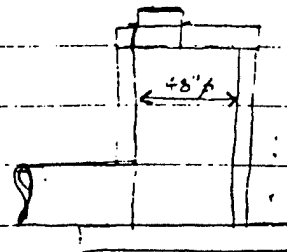
Condition A: Uplift head =  $713 - 698.08 = 14.92'$ 

$$U = (14.92') \left( \frac{\pi}{4} \right) (4.83')^2 (.0625 \text{ kcf}) = 17.09 \text{ k} \uparrow$$

Weight:  $W_s$ 

$$\text{pipe} = (709 - 698.58) (6.885) + 1.68 \text{ base} + 1.11 \text{ top} = 12.01 \text{ k} \downarrow$$

WT. of pipe thru wall not subtracted. Assume this wt. will be there from pipe.



$$F.S. = W_s / U = 12.01 / 17.09 = .70 < 1.5 \text{ need slab extensions}$$

Try 85"  $\phi$  - 2" thick base slab

$$U_{\text{total}} = (.0625) (713 - 697.91) \left( \frac{\pi}{4} (7.08')^2 \right) = 37.13$$

$$W_{g \text{ total}} = (.0625) (713 - 698.58) \left( \frac{\pi}{4} [(7.08')^2 - (4.83')^2] \right) = 18.97$$

$$U - W_g = 18.16$$

 $W_s$ 

$$\text{Concrete: } 9.22 \text{ pipe} + 1.11 \text{ top} + 3.94 \text{ base} = 14.27$$

$$\text{Soil: } [(12 - .0625) (709 - 698.58) - (.0625) (713 - 709)] \left( \frac{\pi}{4} [(7.08')^2 - (4.83')^2] \right) = 7.35$$

$$W_s = 21.62$$

$$F.S. = 21.62 / 18.16 = 1.17 < 1.5 \text{ N.G.}$$

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NRH 1-11-91

✓ GRS 1/91

# Flotation

M.H. 13 (cont)

Try 92"  $\phi$  - 8" thick base slab

$$U = (.0625)(713 - 697.91 \times \frac{\pi}{4})(7.67)^2 = 43.58$$

$$W_g = (.0625)(713 - 698.58)(\frac{\pi}{4})[(7.67)^2 - (4.83)^2] = 25.13$$

$$U - W_g = 18.45$$

$$\text{Concrete: } 9.22 \text{ pipe} + 1.11 \text{ top} + 4.61 \text{ base} = 14.94$$

$$\text{Soil: } [(12 \cdot .0625)(709 - 698.58) - (.0625)(713 - 709) \times \frac{\pi}{4}][(7.67)^2 - (4.83)^2] = 9.73$$

$$W_s = 24.67$$

$$F.S. = W_s / U - W_g = 24.67 / 18.45 = 1.34 \text{ N.G.}$$

Try 92"  $\phi$  - 18" thick base slab

$$U = (.0625)(713 - 697.08 \times \frac{\pi}{4})(7.67)^2 = 45.97$$

$$W_g = \text{from above} = 25.13$$

$$U - W_g = 20.84$$

$$\text{Concrete: } 9.22 + 1.11 + 10.39 = 20.72$$

$$\text{Soil: from above} = 9.73$$

$$30.45$$

$$F.S. = 30.45 / 20.84 = 1.46$$

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NRH 1-11-91

✓ GRS 1/91

# Flotation

M.H. 13 (cont)

Try 96"  $\phi$  - 18" thick base slab

$$U = (.0625) (713 - 697.08) \left(\frac{\pi}{4}\right) (8)^2$$

$$= 50.01 \text{ 48.44}$$

$$W_g = (.0625) (713 - 698.58) \left(\frac{\pi}{4}\right) [(8)^2 - (4.83)^2]$$

$$= 28.79$$

$$U - W_g = 21.23$$

Concrete: 9.22 pipe + 1.11 top + 11.31 base

$$= 21.64 \text{ 17.91}$$

$$\text{Soil: } [(12 \cdot .0625) (709 - 698.58) - (.0625) (713 - 709) \left(\frac{\pi}{4}\right) [(8)^2 - (4.83)^2]]$$

$$= 11.18$$

$$W_s = 32.82$$

$$F.S. = \frac{32.82}{21.23} = 1.55 > 1.5 \text{ ok}$$

Determine net load on slab extension.

$$\text{Uplift pres: } \frac{50.01}{\frac{\pi}{4} (8)^2} = .99 \text{ KSF over entire base}$$

$$U_e = (.99) \left(\frac{\pi}{4}\right) [(8)^2 - (4.83)^2] / \pi (4.83)^2$$

$$= 2.09 \text{ K/FT. at m.H. wall}$$

$$W_{s \text{ conc. slab}} = (.15)(1.5) \left(\frac{\pi}{4}\right) [(8)^2 - (4.83)^2] = 7.19 \text{ K}$$

$$W_g + W_{s \text{ soil}} + W_{s \text{ conc. slab}}$$

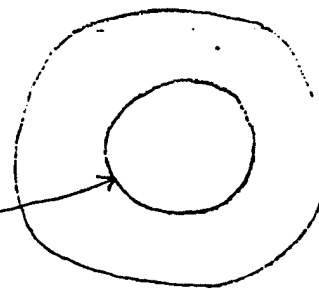
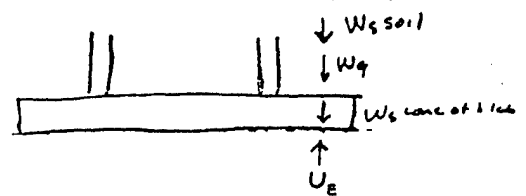
$$= 28.79 + 11.18 + 7.19 / \pi (4.83)^2 = 3.11 \text{ K/FT.}$$

$$\text{Net forced down at wall} = 3.11 - 2.09 = 1.02 \text{ K/FT.}$$

Shear on 18" slab:

$$V_u = 1.7 \times 1.02 = 1.73 \text{ K/FT. } d = 18 - 3.5 = 14.5"$$

$$\phi V_c = (.85) \left( \frac{126}{\sqrt{4000}} \right) (12) (14.5) = 18.64 \text{ K/FT. } 1.73 \text{ K/FT. (OK) } 18" \text{ slab (OK)}$$



✓ GRS 1/91

## Flotation

M.H. 13 (cont.)

→ USE 100"  $\phi$  - 8" thick base slabTry 100"  $\phi$  - 8" thick base slab

$$U = (0.0625)(713 - 697.91) \frac{\pi}{4} (8.33)^2$$

$$= (0.0625)(15.09)(54.50)$$

$$U = 51.40$$

$$(0.0625)(713 - 698.58) \left( \frac{\pi}{4} \right) [8.33^2 - (4.83)^2]$$

$$= (0.0625)(14.42)(36.18)$$

$$W_g = 32.60$$

$$18.80^{\text{K}} \uparrow$$

$$= 15.79$$

Concrete: 9.22 pipe + 1.11 top + 5.46 base

$$\text{Soil: } [(0.0575)(709 - 698.58) - (0.0625)(713 - 707)] \left( \frac{\pi}{4} \right) [8.33^2 - (4.83)^2]$$

$$+ [(0.0575)(10.42) - (0.0625)(4)] \left( \frac{\pi}{4} \right) (36.18)$$

$$= 12.63$$

$$W_s = 28.42^{\text{K}} \downarrow$$

$$F.S. = \frac{W_s}{U - W_g} = \frac{28.42}{18.80} = 1.51 > 1.5 \text{ (ok)}$$

Check strength of slab:

uplift pressure over bottom of slab - slab wt.

$$= 51.40 / \left( \frac{\pi}{4} (8.33)^2 \right) - (15)(0.7) = 94.10 = 184 \text{ KSF}$$

uplift on slab extension

$$U = (84 \text{ KSF}) \left( \frac{\pi}{4} \right) [8.33^2 - (4.83)^2] = 30.48^{\text{K}}$$

$$\text{Net force} = W_g + W_s \text{ soil} - U = 32.60 + 12.63 - 30.48 = 14.75^{\text{K}}$$

$$\text{lever arm} = \frac{(100 - 58)(\frac{1}{2})}{2} = 10.5"$$

$$M = (14.75)(10.5) / \pi (4.83) = 154.84 / 15.17 = 10.2^{\text{K}} \text{ (L.F.)}$$

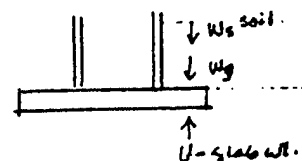
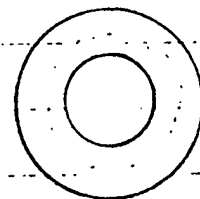
$$8" \text{ slab, } d = 4" \quad \text{max } \rho = 0.007126$$

$$M_u = 1.7 \times 10.2 = 17.35^{\text{K}}$$

$$\phi M_n = (9)(60)(0.007126) \left[ 1 - \frac{(60)(0.007126)}{(1.7)(5)} \right] (12)(4)^2 = 70.17^{\text{K}} > 17.35 \text{ (ok)}$$

$$V_u = 1.7 \times 14.75 / \pi (4.83) = 1.65^{\text{K}} \quad \text{D-59}$$

$$\phi V_c = (1.85)(12 \sqrt{5000})(12)(4) = 5.77^{\text{K}} > 1.65^{\text{K}} \text{ ok}$$



Minimum angle between pipes in round M.H. ✓ GRS 1/91  
Refer to North Star M.H. Barrel size Determination

M.H. 8 36"  $\phi$  + 30"  $\phi$  pipes, 60"  $\phi$  M.H.

$$K = \frac{18" + 4" + 15" + 3.5" + 14"}{\Delta} = \frac{54.5"}{\Delta}$$

Table 1 for 60" M.H.  $K = .52$

$$\min \Delta = 54.5" / K = 54.5" / .52 = 104^\circ \leftarrow \text{min. angle}$$

M.H. 7 30"  $\phi$  + 30"  $\phi$  pipes, 60"  $\phi$  M.H.

$$K = \frac{15 + 3.5 + 15 + 3.5 + 14"}{\Delta} = \frac{51}{\Delta}$$

Table 1 for 60" M.H.  $K = .52$

$$\min \Delta = 51 / K = 51 / .52 = 98^\circ$$

M.H. 13 18"  $\phi$  + 24"  $\phi$  pipes, 48"  $\phi$  M.H.

$$K = \frac{12 + 3 + 9 + 2.5 + 14"}{\Delta} = \frac{40.5}{\Delta}$$

Table 1 for 48"  $\phi$  M.H.;  $K = .42$

$$\min \Delta = 40.5" / .42 = 96^\circ$$

48"  $\phi$  M.H. 24"  $\phi$  + 24"  $\phi$  pipes, feeder pipes from inlets

$$K = \frac{12 + 3 + 12 + 3 + 14"}{\Delta} = \frac{44}{\Delta}$$

Table 1 for 48"  $\phi$  M.H. :  $K = .42$

$$\min \Delta = 44" / .42 = 104^\circ$$

When determining minimum manhole dia. required for various pipe sizes and locations, two general criterias must be met.

- Knowing the relative locations of any two pipes  
compute  $K = \frac{R1 + T1 + R2 + T2 + 14"}{\Delta}$
- MH or CB must be large enough to accept max. pipe as shown in table below.

Where R1 & T1 are interior radius & thickness of Pipe #1  
R2 & T2 are interior radius & wall thickness of Pipe #2  
 $\Delta$  = Angle between pipe in degrees

NOTE: Refer to North Star Plates A-1, or A-3 for wall thickness

Example:

Given: Pipe #1 = 54" I.D., C wall  
Pipe #2 = 48" I.D., C wall  
 $\Delta = 140^\circ$

Check for (a) above.

$$K = \frac{27" + 6.25" + 24" + 5.75" + 14"}{140} = \frac{77"}{140} = .55\%$$

For  $K = .55\%$ , the table below indicates the min. size M.H. Barrel to be 66"

Check for (b) above

For the 66" MH Barrel, the table below indicates a max. pipe size of 42". As the max. size pipe in the example is 54", a 78" MH must be used.

Therefore, for this example, spacing is not critical & the maximum pipe size (criteria b) governs. Had the  $\Delta$  angle been  $113^\circ$  or less, the spacing (criteria a) would be critical & a larger manhole barrel would be required.

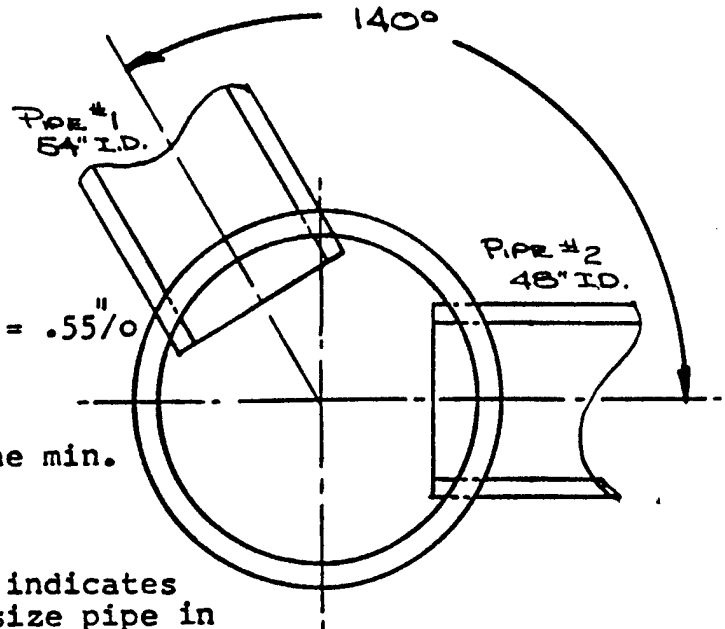


Table I

MH or CB Dia.	K factor %	Max. Pipe Size
27"	.24	15"
42"	.37	24"
48"	.42	27"
54"	.47	33"
60"	.52	36"
66"	.58	42"
72"	.63	48"
78"	.68	54"
84"	.73	60"
90"	.79	60"
96"	.84	60"
102"	.89	60"
108"	.94	60"

- NOTES:
- Formula (a) allows for min. 14" "Leg" between pipes #1 & #2.
  - Should 3 or more pipes be required, each set of pipes should be studied separately with the respective  $\Delta$  angle.
  - It is assumed the flowlines are approximately the same.



APPENDIX E

ARCHITECTURAL MECHANICAL ELECTRICAL

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX E

ARCHITECTURAL-MECHANICAL-ELECTRICAL PUMP STATION DESIGN

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MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX E

ARCHITECTURAL-MECHANICAL-ELECTRICAL PUMP STATION DESIGN

ARCHITECTURAL

1. The pump station, located at the end of Oak Street has been designated by the local sponsor as their "Center of Operations" during a flood emergency. The operations area (superstructure) contains approximately 500 gross square feet and provides an enclosure for the equipment and personnel area, with enough space for the local sponsor to provide a desk and file cabinet for project records. A total of five parking spaces have been provided for employee and emergency vehicles.

2. The pump station derives its design both aesthetically and functionally from the purpose it serves. The brick compliments and is consistent with adjacent residential brick homes in design, detail, and color. The uneven gabled ends are in relation to the the slope of the levee and diminish the superstructure to a more proportional scale, while maintaining the required headroom for the overhead monorail.

3. The roof structure is composed of two glue laminated trusses at the third points of the operations area and treated wood nailers on the concrete end walls. A tongue and groove wood roof deck with a standing seam metal roof will provide low maintenance and a durable finish. The monorail is supported independently of the roof structural system. A steel beam runs from the gabled dormer facing Oak street to the back wall facing the levee. This beam supports the midpoint of the monorail. The ends of the monorail are supported by concrete corbels at the gabled ends.

4. High windows in each of the three gables provide natural light into the station. The double doors on the Southeast side of the station serve two functions: one, to provide access to the monorail while servicing pumps and secondly the active leaf serves as the main entrance into the station. From this entrance point a stairway leads to the forebay operations platform. Ladders with hatch covers lead to lower levels of the forbay and pump chambers.

5. The exterior treatment also includes lighting and metal safety railing. The brick masonry and reinforced concrete walls will provide a low maintenance, fire resistive, weather tight, long life building.

## MECHANICAL

### HYDRAULIC PARAMETERS

6. These parameters establish the physical criteria for designing the pump station.

Required Pumping Capacity - 18,000 gpm.  
River Elevation at Gravity Gate Closure - 706.0 ft.  
Float Setting Elevations -

Common Off	698.0 ft.
1st Pump On	701.5 ft.
2nd Pump On	702.0 ft.
3rd Pump On	702.5 ft.

10 year ponding elevation without pumping - 714.5 ft.  
Maximum River Elevation - 729.0 ft.

### STATION CONFIGURATION

7. The hydraulic parameters warranted the investigation of alternative configurations to include:

Submersible or vertical turbine type pumps.  
Two or three pumps.  
Integral or independent outlet gatewell.

Construction costs were the primary factor for comparing alternatives.

8. The requirement for automatic lubricators rendered the vertical turbine pumps noncompetitive on a cost basis. The submersibles' price advantage was realized in both the two and three pump configurations.

9. Costs for pumps, controls, inlet gates, discharge lines, and substructure were considered in comparing two vs. three pump alternatives. The requirement to maintain two thirds capacity with one pump inoperable established a 12,000 gpm pump size for the two pump alternative. The costs of the two alternatives were effectively equal. The three pump alternative was selected because of its increased redundancy and easier maintenance on the smaller sized equipment.

10. The gatewell and pump station were not combined for several reasons. The primary factor was the unusually deep pumping chamber which would have resulted with an in the levee station. Such a deep chamber (approximately 35 ft.) would have complicated the problems of trash rack raking, pump access, and station flotation. The added depth would have significantly increased construction costs. Locating the station in the levee would have made it less accessible and visually obtrusive.

11. Hydraulic Institute standards were used in sizing the sump and its approaches.

## **PUMPS**

12. The pumps will be submersible centrifugal storm water pumps. Three manufacturers, Flygt, ABS, and KSB have confirmed they can provide pumps complying with typical specifications and with the characteristics required for this project. Standard catalog curves for two suppliers are included with the calculations.

13. A sump pump is provided to dewater the forebay and pump chambers within three hours after the chamber has been drawn down to the minimum level. The sump pump can be removed for maintenance through the forebay access hatch with a portable hoist. A sketch of a portable hoist is included with the calculations.

## **DISCHARGE**

14. The discharges were sized to maintain a velocity of less than 12 fps for required pumping capacities. The pumps discharge into the gate well through flap valves located at the apex of the discharge lines. The discharge lines are ductile iron pipe which is the most economical material for this size line. The discharge lines can drain into the station without causing problems of pump cycling.

## **CRANE**

15. An overhead monorail crane will permit removal of pumps to the open floor area for inspection, maintenance, and if necessary, removal by a service vehicle. The hoist will be slow speed to ensure stability during operation. The monorail beam's location will be adjustable within  $\pm 4$  inches along the station's longitudinal axis to ensure a vertical lift regardless of the actual pump and discharge installed.

## **HEATING AND VENTILATION**

16. Sump ventilation, accomodating changing air volumes due to varying water levels, will be accomplished via motorized louvers located in the front wall of the pump chamber between the two operating levels.

17. Operating room ventilation will be accomplished through a powered exhaust located in the west gable.

18. Heat will be provided by two 5 kw electric space heaters. One will be thermostatically controlled while the other will be on/off controlled for transient conditions.

## **SLUICE GATE OPERATORS**

19. The station's and gate wells' sluice gates will be operated with the portable operator or manually. The portable operator will be stored at the pump station. Factors considered in this decision were reliability, vandalism, construction costs, O&M costs, and operability. The portable operator will be sized for the 72 inch gate at outlet B.

## **OPERATION**

20. The station is considered in operation any time the gravity outlets are closed. It is estimated this will occur once annually with a duration of one week. Minimal trash raking is anticipated because most of the flow is attributable to seepage.

21. Because of the station's depth, the forebay may flood during non flood events. This area can be dewatered with the sump pump if necessary. This area should be dewatered in the autumn to prevent freezing of any remaining water.

22. The substructure can be accessed through the pump chamber, forebay, and inlet chamber. Access is provided for inspection and repair purposes.

23. The pump chamber can be accessed for inspection purposes during operation. Ladders allow access to the discharge flange.

#### MECHANICAL REFERENCES

EM 1110-2-1410 Interior Drainage of Leveed Urban Areas: Hydrology, May 1965.

EM 1110-2-3102 General Principles of Pumping Station Design and Layout, December 1962.

EM 1110-2-3105 Mechanical & Electrical Design of Pumping Stations, December 1962.

#### ELECTRICAL

##### SERVICE

24. Electric power for the pumping station will be supplied by The City of Chaska Utility, the utility will provide 3-phase, 277/480-volt secondary electrical service to the storm water pump stations. They will install a padmount transformers adjacent to the pump station. The Construction contract will be required to construct a concrete pad in accordance with the cities specifications. The Utility will not permit full voltage starting of the pump motors used on this project. Reduced voltage starters will be required. The pumping station will receive underground, 3-phase, 277/480-volt secondary power. The service capacities for the station will be in accordance with the "Demand Load Analysis". The electrical equipment will be protected with suitable lightning arrestors.

25. The anticipated electrical loads will consist of:

submersible pumps - 3-100 hp

overhead crane - 2 hp

sum pump - 2 HP

electric heaters - 2-5 KW

sanitary lift pumps 2 - 10 hp (design and specification provided by the city)

26. The main circuit breakers will be key interlocking, with one breaker for the service from the power company and the other will be connected to a NEMA 4 junction box. The junction box will be mounted on the outside wall

of the station and have terminal lugs for connection of a city provided generator during power outages.

#### **STATION POWER AND LIGHTING**

27. The station will have a 100 amp 240/120 panel for lighting, and 120-volt convenience outlets. The station will have several 120 volt duplex GFI receptacles in the structure. A separate circuit will provide power to exterior GFI receptacles. This circuit can be shut off during times of non-use so unauthorized personnel can not use them. Interior lighting will provide approximately 40 footcandles of light, there will also be an emergency light in case of power failure.

28. Exterior lighting will be provided near the doors and the gate operators.

#### **PUMP MOTORS**

29. The stormwater submersible pump motors will be housed in an air or oil-filled watertight casing and will have Class F insulated moisture resistant windings. Each motor will be equipped with temperature sensors for bearing and stator thermal protection and leak detectors for seal failure.

30. The motors will be designed to operate on a three-phase, 480-volt electrical system. The pump motors will have cooling characteristics suitable to permit continuous operation in a totally, partially, or non-submerged condition.

#### **CONTROL SYSTEM AND CONTROL PANEL**

31. Motor Control Center. The pump control equipment will be housed in free-standing motor control center. The enclosures will be fabricated from 12 gauge, cold rolled, hot-dipped galvanized steel with a gray baked enamel finish. Motor control sections shall be multiples of 20" wide by 20" deep by 90" high. The enclosures will be a NEMA 1 type. The motor control section shall be wired as a NEMA Class II type C with pull apart terminal blocks between sections. Power sections shall be constructed with horizontal and vertical bus enclosed in separate compartments with bus barriers for vertical and horizontal bus. The control operators, indicators and meters will be mounted on section doors, they will not be mounted below 30 inches or above 78 inches from the floor. The function of all major components and sub-assemblies will be identified with laminated, engraved plastic nameplates.

32. The city designed and specified control system for the relocated sanitary lift station shall be incorporated in the Motor Control Center. A telementary system incorporated in the Motor Control Center shall be provided for both the storm water and sanitary pump alarms. The following equipment will be furnished in the motor control center:

- 1) A Underwriter's Laboratories "Service Equipment Listed" main disconnect.

2) A three-phase, lightning and surge arrestor connected to phase conductors on the "Line" side of the service disconnect. The arrestor will protect the control panels against damage due to power system lightning strikes and surges.

3) A phase-sequence, phase-loss, under-voltage protection relay with adjustable nominal voltage settings complete with three extractor type line voltage fuses. This device will drop-out the pump if all phase voltages drop below 90% or if one phase drops below 80-83% nominal voltage. This device will have a 1/2 second dropout delay and an adjustable restoration time delay of up to five minutes.

4) A thermal magnetic molded case circuit breaker rated 22,000 amps-interrupting-current for short circuit protection of each pump motor.

5) A reduced-voltage magnetic motor starter with melting-element, ambient-compensated, quick-trip overload to provide overcurrent and running overload protection for each pump motor.

6) A door mounted "Hand-Off-Automatic" three position, rotary, oil-tight, weather-tight, heavy duty, NEMA 4 selector switch for each pump.

7) A door mounted "Pump Running" light operated from a motor starter auxiliary contact for each pump.

8) A control power circuit breaker.

9) A 100-watt, 120-volt condensation, "Strip" heater and adjustable thermostat for each motor control center section.

10) A running time meter measuring hours and tenths of hours of operation up to 9999.9 hours for each pump motor. These will be 110-volt, A.C. devices operating from the panel control voltage via an auxiliary contact of the motor starters.

11) Wet well level responsive automatic pump control and alarm system using five direct-acting liquid level sensors in the wet well. The Controller/Alternator will have five sensor test switches and indicating LED's, solid state alternation logic, lead pump alternation on successive starts, alternator manual over-ride control (Auto, 1-2-3, 2-3-1, 3-2-1), high level alarm and pump control load relays, independent "ON" and common "OFF" pump control.

12) A exterior mounted weatherproof, high water alarm horn and light. The alarm light will be the dim glow type and will glow brightly upon occurrence of an alarm condition.

13) Pump motor temperature and moisture sensing protective devices and control circuitry with manual reset to alarm and shut-down a pump in the event of abnormal operation.

33. Liquid Level Sensors. Level sensors will consist of a mercury switch mounted within a 5-1/2" diameter, type 316, stainless steel float assembly. The mercury switches will be rated for 20-amps at 120-volts. The supporting



control power cables will be extra-flexible with type "HSO" insulation jackets. The floats will be suspended in the wet well from a cable rack.

#### WIRE AND CABLE

34. The wire and cable used will be in accordance with guide specifications CE-1404.04, Insulated Wire and Cable (for Hydraulic Structures). Conductor material will be copper. Conductors will not be smaller than No. 12 A.W.G. Aluminum Conductors will not be permitted.

35. Conductors will be installed in conduit. Power cables will be sized for current-carrying capacity and voltage drop.

#### GROUNDING

36. All equipment will be grounded in accordance with the current edition of the National Electrical Code, NFPA 70 including connections to the steel hatch covers and discharge piping.

# MECHANICAL ANALYSIS

## PUMPING CONFIGURATION.

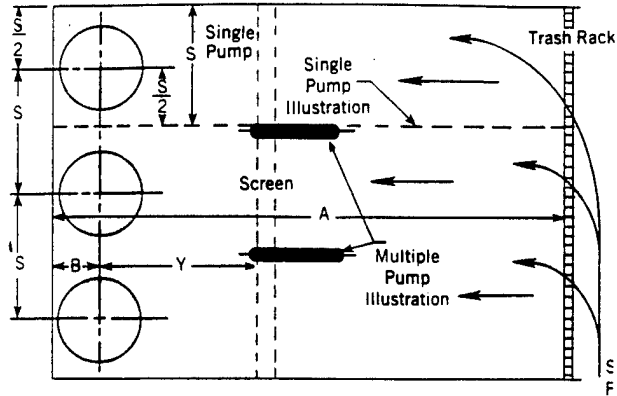
Determine the type (ie. radial, mixed, or axial flow) of pump based on capacity and head.

Number of Pumps	2	3
Capacity per pump (g.p.m.)	12,000	6,000
Approximate length of discharge line	120	120
Diameter of discharge line assuming 12 f.p.s.	20.2"	14.3"
$12 \times ((4 \times Q) / (11 \times 12 \times 449))^{.5}$	(24")	(16")
Equivalent length of fittings (ft.)	169.8'	111'
24" 16"	60.4'	40'
3 - 90s @ 56.6'	37'	
2 - 45s @ 30.2'	20'	
Friction loss per 100 ft. (ft.)	0.962'	2.01'
Velocity Head (ft.)	1.42'	1.84'
Static Head (ft.) 729 - 698	31'	31'
TDH = 1.05 x (s.h. + v.h. + line losses)	35.8'	38.3'
BHP = gpm x TDH / (3960 x eff) eff = .7	155 hp	83 hp
Maximum pump speed (rpm)	993	1400

The heads could be achieved with either a mixed or radial flow pump. After comparing costs, vertical turbine pumps (with automatic lubricators) were eliminated. Therefore submersible pumps. Only one source carries a submersible mixed flow pump in these capacities. Therefore radial flow.

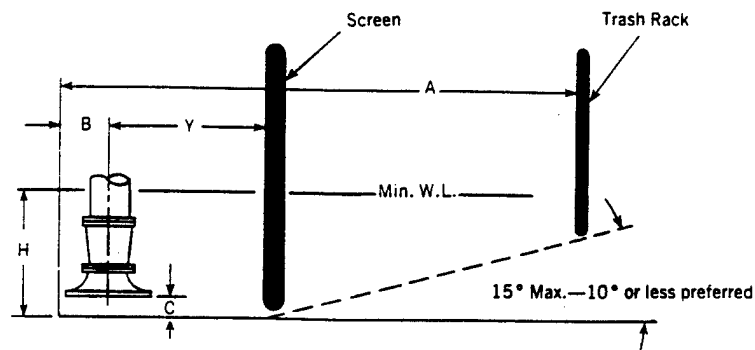
## MECHANICAL ANALYSIS

Determine whether two or three pumps based on construction costs.

Number of Pumps	2	3
	6-8 kgpm	12-14 kgpm
		
A	140"	200"
B	23+(50)"	33+(50)"
C	18"	22.5"
H	60"	80"
S	56"	73"
Y	95"	130"

Number of Pumps	2	3
Sump	\$63k	\$55k
Controls	\$45k	\$40k
Pumps	2 x \$67k	3 x \$35k
Discharge cost per linear foot	117 x 2 x \$76	3 x \$35
	\$18k	\$15k
Fittings (4 90s)	\$17.6k	\$8.6k
Gates & Operators	2 x \$5k	3 x \$3k
	=====	=====
	\$287k	\$245k

The three pump option is economically justifiable.



## MECHANICAL ANALYSIS

### PUMP CYCLE TIME.

Ton = TOTAL MINUTES PUMP ON  
Toff = TOTAL MINUTES PUMP OFF  
Tcycle = TOTAL CYCLE TIME  
V = PUMPING VOLUME BETWEEN H.W.L. AND L.W.L.  
P = PUMPING RATE  
Q = INFLOW  
N = NUMBER OF PUMPS  
PHI = CYCLES/HOUR

Critical inflow equals 1/2 the pumping rate. This inflow will cause the highest cycle frequency. Ton = Toff.

$$P = 6000 \text{ gpm.}$$

$$Q = P/2 = 3000 \text{ gpm}$$

$$V = 15 \frac{2}{3}' \times 27 \frac{2}{3}' \times (706 - 698) = 3,468 \text{ ft}^3 = 25,941 \text{ gals.}$$

$$\text{Ton} = 25,941 / (6,000 - 3,000) = 8.65 \text{ minutes.}$$

$$\text{Tcycle} = \text{Ton} + \text{Toff} = 2 \times \text{Ton} = 17.3 \text{ minutes.}$$

$$\text{PHI} = 60 / (\text{Tcycle} \times N) = 60 / (17.3 \times 3) = 1.2 \text{ cycles per hour.}$$

# PERFORMANCE CURVES.

REFER TO PAGE 1 FOR PUMP VERSION (H.H., STD., etc.) and PUMP TYPE (CP, CT, etc.)

SECTION

PAGE

3355

8B

SUPERSEDES

ISSUED

9/83

CP/CT-3355

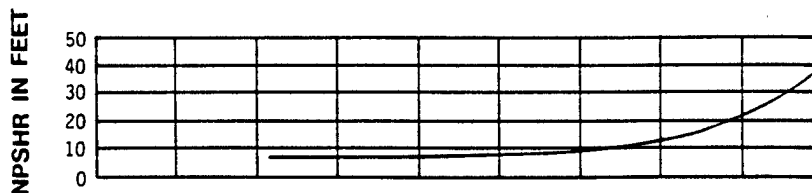
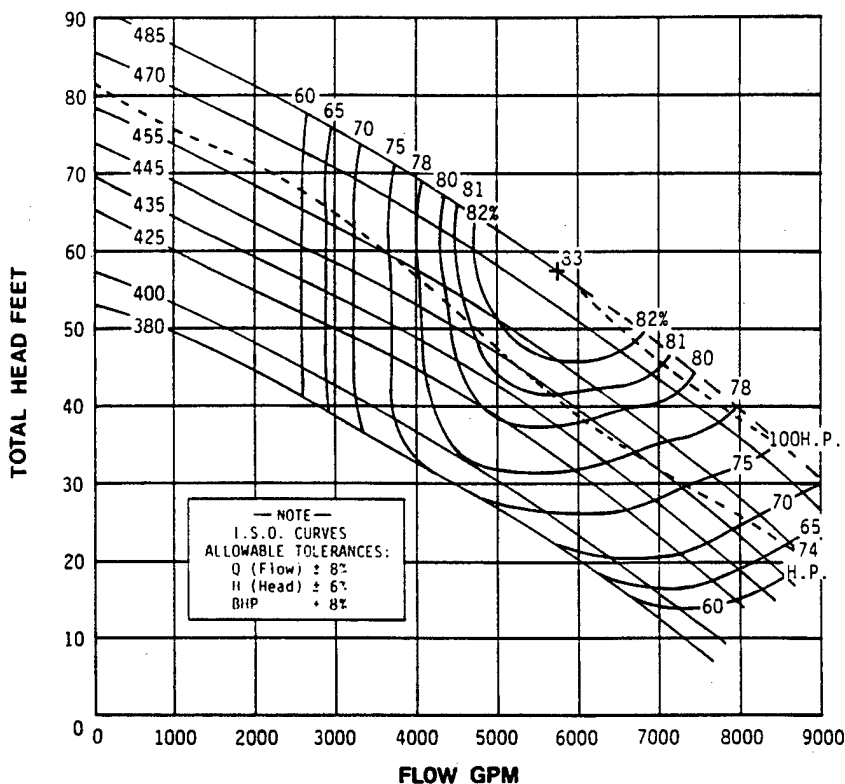
DETERMINE THE SYSTEM OPERATING SPAN ON THE PUMP CURVE SELECTED.  
ALL PUMP CURVES OR PORTIONS OF PUMP CURVES BELOW THE 74 HP CURVE REQUIRE THE 74 HP MOTOR.  
ALL PUMP CURVES OR PORTIONS OF PUMP CURVES ABOVE THE 74 HP CURVE AND BELOW THE 100 HP CURVE REQUIRE THE 100HP MOTOR ETC.

TO FIGURE KW INPUT AT DUTY POINT:

$$\text{Input KW} = \frac{\text{GPM} \times \text{Hd. in Ft.} \times .746}{3960 \times \text{Hyd. Eff.} \times \text{Motor. Eff.}}$$

Consult Flygt Tech. Dept.  
For Motor Information

WASTEWATER IMPELLER  
810



PERFORMANCE CURVES ARE BASED ON TESTS  
WITH CLEAR WATER AT AMBIENT TEMPERATURE.



FLYGT CORPORATION  
A DIVISION OF IIT  
129 GLOVER AVE., NORWALK, CT. 06856

Total Head  
[ft]



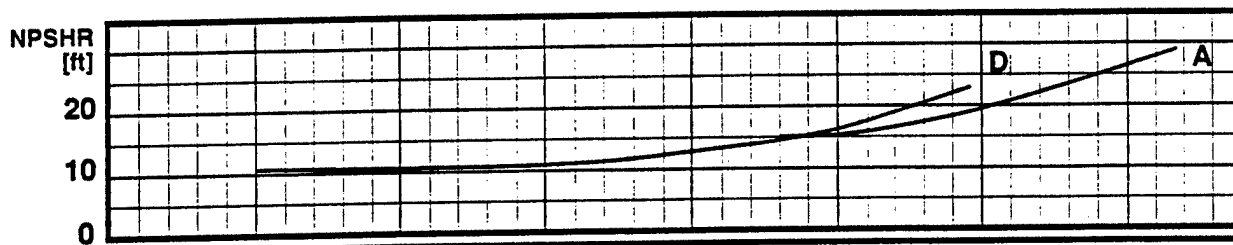
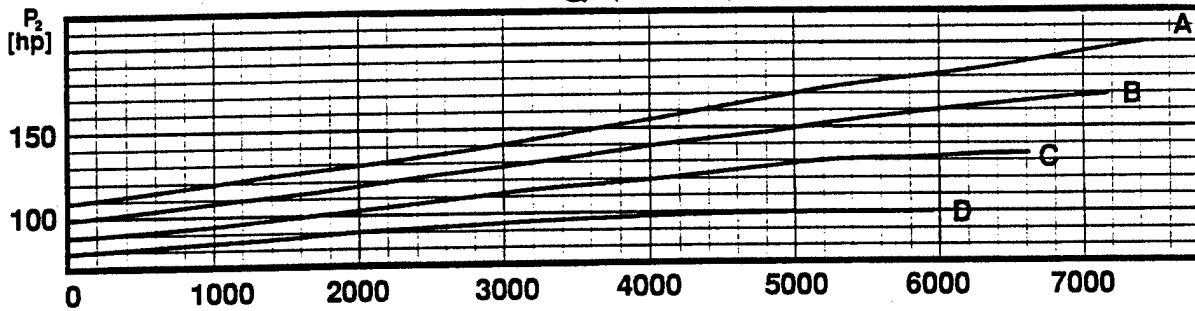
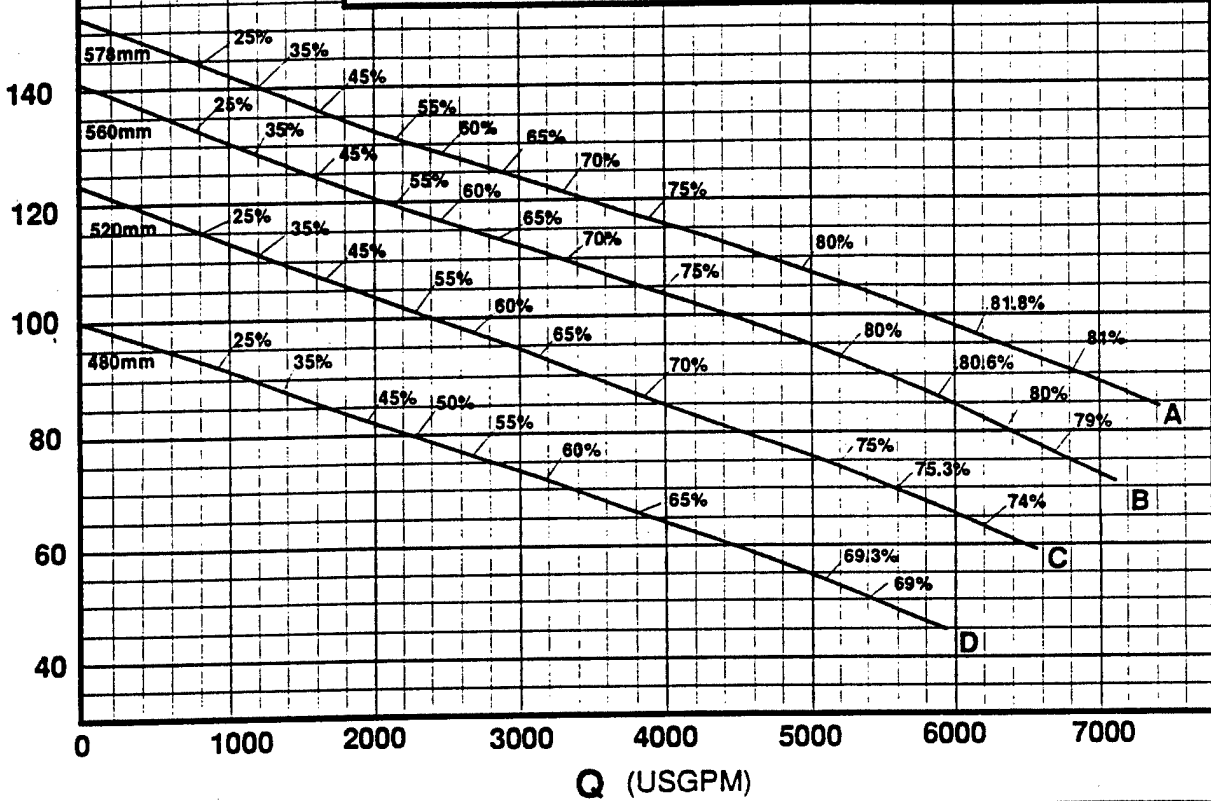
**MODEL AF  
RATED HP**

DATE March 1, 1988

**STANDARD**

750-8.W3.	900-8.W3.	1100-8.W4.	1320-8.W4.	1600-8.W4.
101	121	148	177	215

SOLID SIZE 6" BLADE 2 SPEED 870 RPM  
DISCHARGE SIZE 14" VOLTAGE 460,600 60 Hz 3 PH



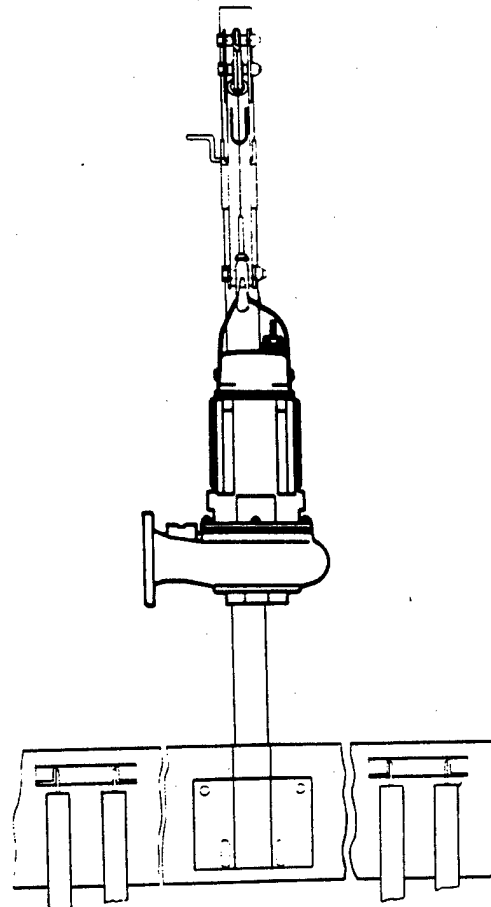
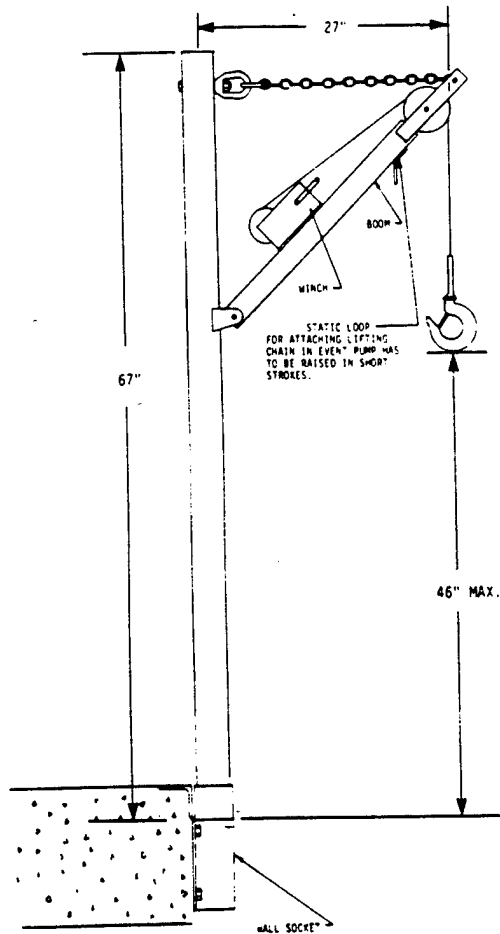
Hydraulic type: Closed impeller  
Wet end: GS 351

Discharge Size **14"**

ABS Pumps Inc. 140 Pond View Drive Meriden, CT 06450

# PORTABLE HOIST

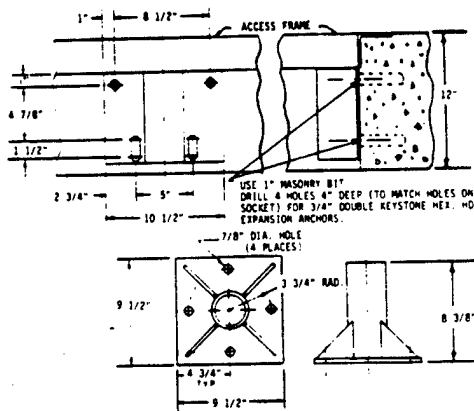
SECTION	PAGE
K	22
SUPERSEDES	ISSUED
	4/86



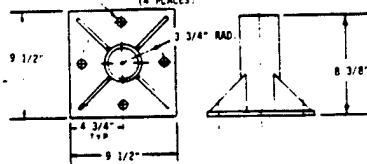
## NOTES:

1. LUBRICATE INTERIOR SURFACE AND SHOULDER OF SOCKET WITH AXLE GREASE TO FACILITATE ROTATION OF HOIST.
2. MINIMUM CONCRETE DEPTH REQUIRED FOR WALL MOUNT INSTALLATION IS 12" - IF EXISTING PIT HAS LESS THAN 12" WALL, REFER TO ALTERNATE INSTALLATION DRAWING # 14587832.
3. SEE DRAWING # 14587831 FOR TYPICAL DUPLEX INSTALLATION OF WALL SOCKET.
4. PLATFORM SOCKET INSTALLATION DRAWING # 14587830.

## WALL SOCKET (14587850)



## PLATFORM SOCKET (14587840)



## SPECIFICATIONS:

SAFE LOAD 650 LBS

WEIGHT: 60 LBS.

LIFT: 30 FT.

REACH: 27" MAX.



**FLYGT CORPORATION**  
A SUBS. CO. OF ITT  
129 GLOVER AVE., NORWALK, CT. 06856

MINNESOTA RIVER AT CHASKA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

DEMAND LOAD ANALYSIS



DATE: 1 10 91  
TIME: 8 38 AM

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DAPPER ( DEMAND LOAD ANALYSIS MINI/MICRO VERSION 3.4 LEVEL 2.1)  
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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

# LOAD SUMMARY

\*\*\*\*\*

LOAD SCHEDULE FOR 1 PRI UTIL 13800. VOLTS LINE TO LINE  
SOURCE OF PWR \*\*\*\*\* SOURCE BUS

ITEM DESCRIPTION	* CONNECTED KVA	LOAD AMPS	* DEMAND KVA	LOAD AMPS	* DESIGN KVA	LOAD AMPS	* % P F
BRANCH LOADS							
2 SEC	357.9	15.0	357.9	15.0	383.6	16.0	-80.6
TOTALS	357.9	15.0	357.9	15.0	383.6	16.0	-80.6

LOAD SCHEDULE FOR 2 SEC 480. VOLTS LINE TO LINE  
SOURCE OF PWR 1 PRI UTIL

ITEM DESCRIPTION	* CONNECTED KVA	LOAD AMPS	* DEMAND KVA	LOAD AMPS	* DESIGN KVA	LOAD AMPS	* % P F
BRANCH LOADS							
3 MCC	357.9	430.4	357.9	430.4	383.6	461.4	-80.6
TOTALS	357.9	430.4	357.9	430.4	383.6	461.4	-80.6

LOAD SCHEDULE FOR 3 MCC 480. VOLTS LINE TO LINE  
SOURCE OF PWR 2 SEC

ITEM DESCRIPTION	* CONNECTED KVA	LOAD AMPS	* DEMAND KVA	LOAD AMPS	* DESIGN KVA	LOAD AMPS	* % P F
END USE LOADS							
MOTOR LOADS	235.1	282.8	235.1	282.8	235.1	282.8	-80.0
LARGEST MOTOR	103.1	124.0	103.1	124.0	128.9	155.0	-80.0
BRANCH LOADS							
4 HEATER	10.0	12.0	10.0	12.0	10.0	12.0	-90.0
5 PANEL	10.0	12.0	10.0	12.0	10.0	12.0	-90.0
TOTALS	357.9	430.4	357.9	430.4	383.6	461.4	-80.6

LOAD SCHEDULE FOR 4 HEATER 480. VOLTS LINE TO LINE  
SOURCE OF PWR 3 MCC

ITEM DESCRIPTION	* CONNECTED KVA	LOAD AMPS	* DEMAND KVA	LOAD AMPS	* DESIGN KVA	LOAD AMPS	* % P F
END USE LOADS							
GENERAL LOADS	10.0	12.0	10.0	12.0	10.0	12.0	-90.0
TOTALS	10.0	12.0	10.0	12.0	10.0	12.0	-90.0

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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

LOAD SUMMARY

\*\*\*\*\*

LOAD SCHEDULE FOR 5 PANEL 480. VOLTS LINE TO LINE  
SOURCE OF PWR 3 MCC

ITEM DESCRIPTION	* CONNECTED KVA	LOAD AMPS	* DEMAND KVA	LOAD AMPS	* DESIGN KVA	LOAD AMPS	* % P F
END USE LOADS							
GENERAL LOADS	10.0	12.0	10.0	12.0	10.0	12.0	-90.0
TOTALS	10.0	12.0	10.0	12.0	10.0	12.0	-90.0

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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

SOURCE LOAD SUMMARY

\*\*\*\*\*

LOAD BUS 1 PRI UTIL		13800. VOLTS LINE TO LINE			
LOAD DESCRIPTION TYPE	UNITS	CONNECTED LOAD	DEMAND LOAD	DESIGN LOAD	POWER FACTOR %
GENERAL LOADS	KW	18.0	18.0	18.0	
	KVAR	-8.7	-8.7	-8.7	
	KVA	20.0	20.0	20.0	90.0 LAGGING
MOTOR LOADS	KW	188.1	188.1	188.1	
	KVAR	-141.1	-141.1	-141.1	
	KVA	235.1	235.1	235.1	80.0 LAGGING
LARGEST MOTOR	KW	82.5	82.5	103.1	
	KVAR	-61.9	-61.9	-77.3	
	KVA	103.1	103.1	128.9	80.0 LAGGING
TOTAL LOADS	KW	288.6	288.6	309.2	
	KVAR	-211.6	-211.6	-227.1	
	KVA	357.9	357.9	383.6	
	% PF	80.6	80.6	80.6	
		LAGGING	LAGGING	LAGGING	

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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

LOAD DEMAND TABLE

LOAD DESCRIPTION	LOAD TYPE	FIRST DEMAND KVA	FIRST DEMAND %	SECOND DEMAND KVA	SECOND DEMAND %	THIRD DEMAND KVA	THIRD DEMAND %	% PF	DESIGN FACT
GENERAL LOADS	K	100.	100.	ALL	50.	ALL	50.	-90.0	1.00
LIGHTING	K	ALL	100.	ALL	100.	ALL	100.	-95.0	1.25
RECEPTACLES	Z	10.	100.	ALL	50.	ALL	50.	-95.0	1.00
OFFICE EQUIPMENT	Z	ALL	100.	ALL	100.	ALL	100.	-85.0	1.00
HEATING	Z	ALL	100.	ALL	100.	ALL	100.	100.0	1.25
STANDBY LOADS	K	ALL	100.	ALL	100.	ALL	100.	-85.0	1.25
CAPACITOR BANK	Z	ALL	100.	ALL	100.	ALL	100.	.0	1.35
SYNC. MOTOR	K	ALL	100.	ALL	100.	ALL	100.	100.0	1.25
MOTOR LOADS	K	ALL	100.	ALL	100.	ALL	100.	-80.0	1.00
LARGEST MOTOR	K	ALL	100.	ALL	100.	ALL	100.	-80.0	1.25

NOTES: LOAD TYPE 10 PROVIDES TRANSFER FUNCTION TO LOAD TYPE 9  
DEMAND AND DESIGN FACTORS APPLIED AT EACH LOAD BUS  
AND ALL LOAD TOTALS ARE POWER FACTOR CORRECTED

MINNESOTA RIVER AT CHASKA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

SHORT CIRCUIT ANALYSIS

CHASKA

US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

DATE: 1 10 91  
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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

C O N T R I B U T I O N   D A T A

CONTRIBUTION FROM NAME	NO	NAME	VOLTAGE L-L	BASE MVA	XD" (PU)	X/R
CITY CHASK	1	PRI UTIL	13800.	3P-KA:	37.653	30.0
		ANSI TYPE: UTILITY		1P-KA:		
		POS SEQUENCE IMPEDANCE			.00370 + J	.11105 PER UNIT
PUMP 1	3	MCC	480.	.100	.25000	15.0
		ANSI TYPE: IND. MOTOR HP:	100.	RPM: 1800.		
		POS SEQUENCE IMPEDANCE			16.66667 + J	250.00000 PER UNIT
PUMP 2	3	MCC	480.	.100	.25000	15.0
		ANSI TYPE: IND. MOTOR HP:	100.	RPM: 1800.		
		POS SEQUENCE IMPEDANCE			16.66667 + J	250.00000 PER UNIT
PUMP 3	3	MCC	480.	.100	.25000	15.0
		ANSI TYPE: IND. MOTOR HP:	100.	RPM: 1800.		
		POS SEQUENCE IMPEDANCE			16.66667 + J	250.00000 PER UNIT



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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

F E E D E R   D A T A

FEEDE R FROM		FEEDE R TO		QTY	VOLTS	LENGTH	FEEDE R	DESCRIPTION
NO	NAME	NO	NAME	/PH	L-L	FEET	SIZE TYPE	DUCT INSUL
2 SEC		3 MCC		2	480.	75.	500 C	M THWN
POS	SEQ Z	.0294 + J		.0466	OHMS/M FEET		.47852 + J	.75846 PU
3 MCC		4 HEATER		1	480.	30.	12 C	M THWN
POS	SEQ Z	1.8700 + J		.0910	OHMS/M FEET		24.34896 + J	1.18490 PU
3 MCC		5 PANEL		1	480.	30.	14 C	N THWN
POS	SEQ Z	2.9700 + J		.0961	OHMS/M FEET		38.67188 + J	1.25130 PU

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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

T R A N S F O R M E R     D A T A

PRIMARY RECORD				* SECONDARY RECORD						
NO	NAME	CONN	VOLTS L-L	PRI FLA	NO	NAME	CONN	VOLTS L-L	SEC FLA	NOMINAL KVA
1	PRI UTIL	Y	13800.	21.	2	SEC	YG	480.	601.	500.0
POS	SEQ Z	1.0000	+ J	4.8989	PERCENT		2.00000	+ J	9.79780	PER UNIT

DATE: 1 10 91  
CHASKA

TIME: 8 41 AM

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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

T H R E E   P H A S E   F A U L T   R E P O R T

1 PRI UTIL	FAULT: 37698.	RMS SYM AMPS,	901060. KVA	X/R:	29.945
	VOLTAGE: 13800.	IMPEDANCE TO GND=	.00705 + J		.21123 OHMS
	CONTRIBUTIONS:	CITY CHASK	37653. AMPS	X/R:	30.000
		2 SEC	44. AMPS	X/R:	11.686
2 SEC	FAULT: 13314.	RMS SYM AMPS,	11069. KVA	X/R:	5.318
	VOLTAGE: 480.	IMPEDANCE TO GND=	.00385 + J		.02046 OHMS
	CONTRIBUTIONS:	1 PRI UTIL	11898. AMPS	X/R:	4.945
		3 MCC	1427. AMPS	X/R:	13.936
3 MCC	FAULT: 12406.	RMS SYM AMPS,	10314. KVA	X/R:	4.694
	VOLTAGE: 480.	IMPEDANCE TO GND=	.00465 + J		.02185 OHMS
	CONTRIBUTIONS:	PUMP 1	480. AMPS	X/R:	15.000
		PUMP 2	480. AMPS	X/R:	15.000
		PUMP 3	480. AMPS	X/R:	15.000
		2 SEC	10982. AMPS	X/R:	4.297
4 HEATER	FAULT: 4229.	RMS SYM AMPS,	3516. KVA	X/R:	.405
	VOLTAGE: 480.	IMPEDANCE TO GND=	.06075 + J		.02458 OHMS
	CONTRIBUTIONS:	3 MCC	4229. AMPS	X/R:	.405
5 PANEL	FAULT: 2858.	RMS SYM AMPS,	2376. KVA	X/R:	.264
	VOLTAGE: 480.	IMPEDANCE TO GND=	.09375 + J		.02473 OHMS
	CONTRIBUTIONS:	3 MCC	2858. AMPS	X/R:	.264

DATE: 1 10 91  
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US ARMY CORP OF ENGINEERS - ST. PAUL, MINNESOTA

F A U L T   S T U D Y   S U M M A R Y

BUS RECORD NO NAME	VOLTAGE L-L	AVAILABLE FAULT DUTIES 3 PHASE      LINE/GRND
1 PRI UTIL	13800.	37698.
2 SEC	480.	13314.
3 MCC	480.	12406.
4 HEATER	480.	4229.
5 PANEL	480.	2858.

5 BUSES,      8 BRANCHES,      4 CONTRIBUTIONS  
\*\*\* SHORT CIRCUIT STUDY COMPLETE \*\*\*

APPENDIX F

CONSTRUCTIBILITY

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX F

CONSTRUCTIBILITY

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Major Construction Activities	F-1	2
Construction Scheduling Considerations	F-1	3
Water Control		
Ground Water	F-2	4
River Water	F-2	5
Utility Modification Schedule	F-2	6
Traffic Considerations	F-3	7,8
Construction Materials	F-3	9
Disposal Areas	F-3	10
Plates F-1 and F-2		

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX F

CONSTRUCTIBILITY

INTRODUCTION

1. This appendix presents the construction aspects of the proposed flood control improvements on the Minnesota River at Chaska Minnesota. Information is presented on major construction activities, scheduling, water control, utility modifications, traffic considerations, construction material, and disposal areas.

MAJOR CONSTRUCTION ACTIVITIES

2. Stage 4 of the flood control project consists primarily of a levee that protects Chaska from flooding of the Minnesota River and related interior drainage facilities that consist of a storm water pumping station, interceptor, and outlet pipes with gatewells. The work includes the following major construction activities:

- a. Construction of about 271,000 CY of impervious levee.
- b. Construction of about 414,000 LF of wick drains.
- c. Construction of about 8,200 CY of riprap and bedding.
- d. Construction of one 18,000 gpm storm water pump station.
- e. Construction of about 4,600 LF of RCP between 18" and 72".
- f. Construction of about 14 manholes and 16 inlets.
- g. Construction of about 36 relief wells with 12" RCP outlet.
- h. Construction of two gatewells.

These activities can be accomplished using ordinary construction equipment and methods.

CONSTRUCTION SCHEDULING CONSIDERATIONS

3. The construction of this project is scheduled to start in January 1993 and be completed in August 1994. The construction contractor will be responsible for the construction schedule and be required to prepare and receive approval on a network analysis system that shows his proposed construction schedule. Construction items that will require special consideration include:

- a. Levee between station 0+00 and 30+00.
- b. New sanitary sewer between stations 32+00 and 71+00.
- c. Levee between stations 60+00 and 70+00.
- d. Outlet ends of Outlets B and C.

All operations affected by the Minnesota River shall be scheduled to take

advantage of favorable river stages. Also the existing drainage facilities shall not be removed or otherwise rendered nonfunctional prior to operation of the permanent project facilities or installation of approved temporary facilities.

#### WATER CONTROL

##### GROUND WATER

4. It is anticipated that some of the proposed interceptor pipe will lie below the normal ground water table. Sump pumps or well points will be used to lower the ground water. That portion of Outlet B and C that is riverward of the Gatewells is about 10 to 15 feet below the normal ground water table. It is expected that dewatering wells will be required to lower the ground water level for this portion of the gatewells and outlet construction. Because of the pervious nature of the subsurface soils the normal ground water level is influenced by Minnesota River levels and more extensive dewatering systems will be necessary during above normal river stages.

##### RIVER WATER

5. The outlet ends of Outlet B and C lie below the normal low Minnesota River level and will require construction of cofferdams to complete.

#### UTILITY MODIFICATION SCHEDULE

6. Table F-1 summarizes the required telephone, electric, gas, sewer, and water utility modifications required.

TABLE F-1

#### UTILITY MODIFICATION SCHEDULE

<u>STATION</u>	<u>UTILITY</u>	<u>SUMMARY</u>
48+65,49+50,51+50, 53+80,57+40,57+45, 57+50,57+55,61+30, 63+60,63+70,65+50,	Utility pole	Remove and replace
29+10	NSP 69 KV Trans. line	Modify guy wire
50+50	Under grd teleph	Modify
57+50,65+50	Overhead teleph	Modify
48+10	San.lift station	Construct
48+00,52+00,55+00, 59+50	Hydrants	Relocate
48+10 to 71+20	12" sanitary	Construct
34+00 to 48+10	8" san. force	Construct



#### TRAFFIC CONSIDERATIONS

7. Access to the project between station 0+00 and 32+00 will be by an existing private farm road at station 7+50. Access to the project between stations 32+00 and 77+00 will be by existing city streets. The contractor will be required to maintain local traffic at station 7+50 for farm operations, at station 31+00 through 34+50 for pedestrians, at station 34+60 for farm operations, and at station 60+00 for boat docking access. Closure of Minnesota Highway 41 at station 56+00 will not be allowed.

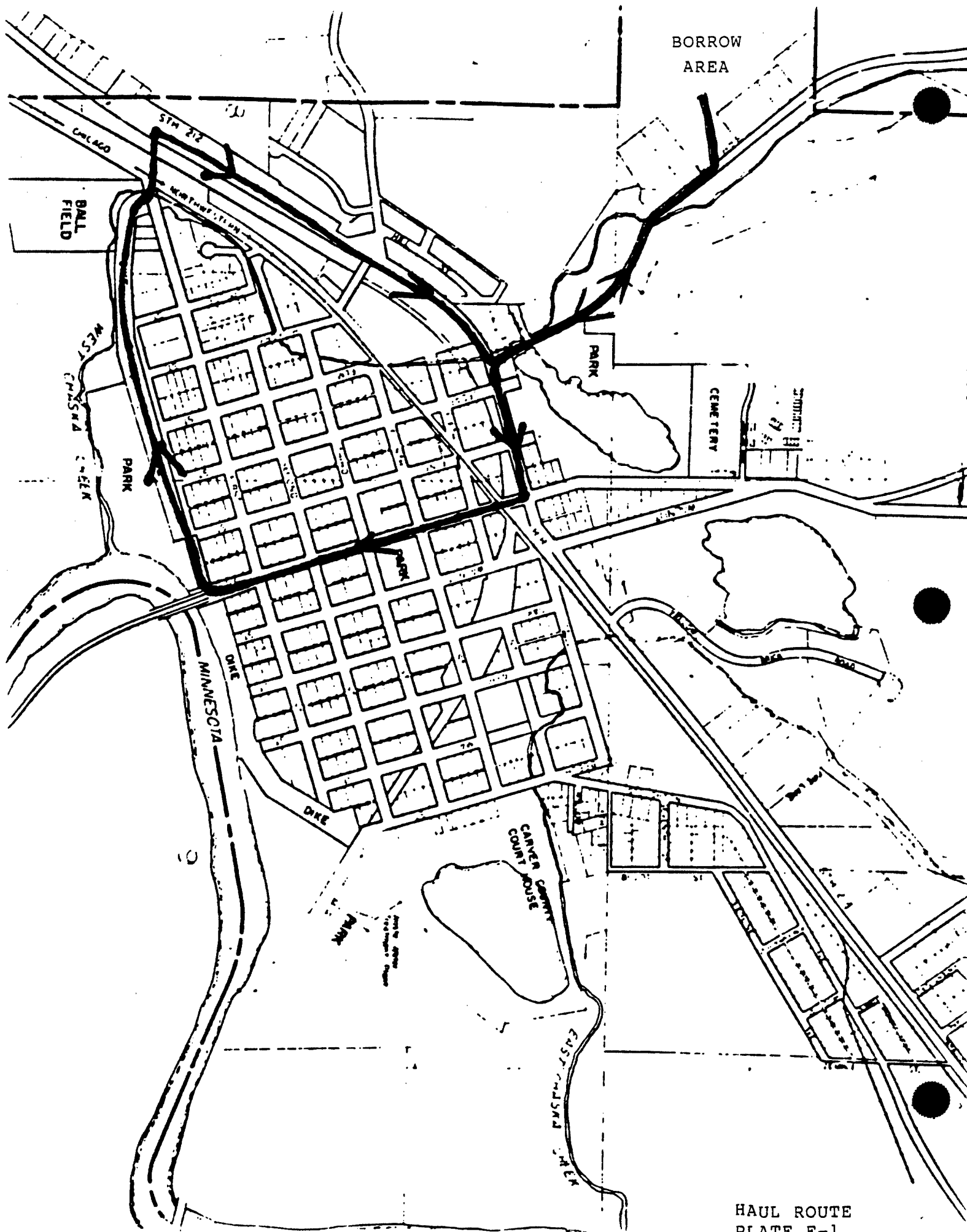
8. When continuous haul operations result in hazard to traffic on streets and highways, the contractor shall erect warning signs and provide flagging services as necessary to safeguard the public. Haul roads shall be maintained by the contractor and kept free of debris. The designated haul roads from the impervious borrow area are shown on Plates F-1 and F-2. In general these haul routes shall be used for hauling all materials to and from the construction site.

#### CONSTRUCTION MATERIALS

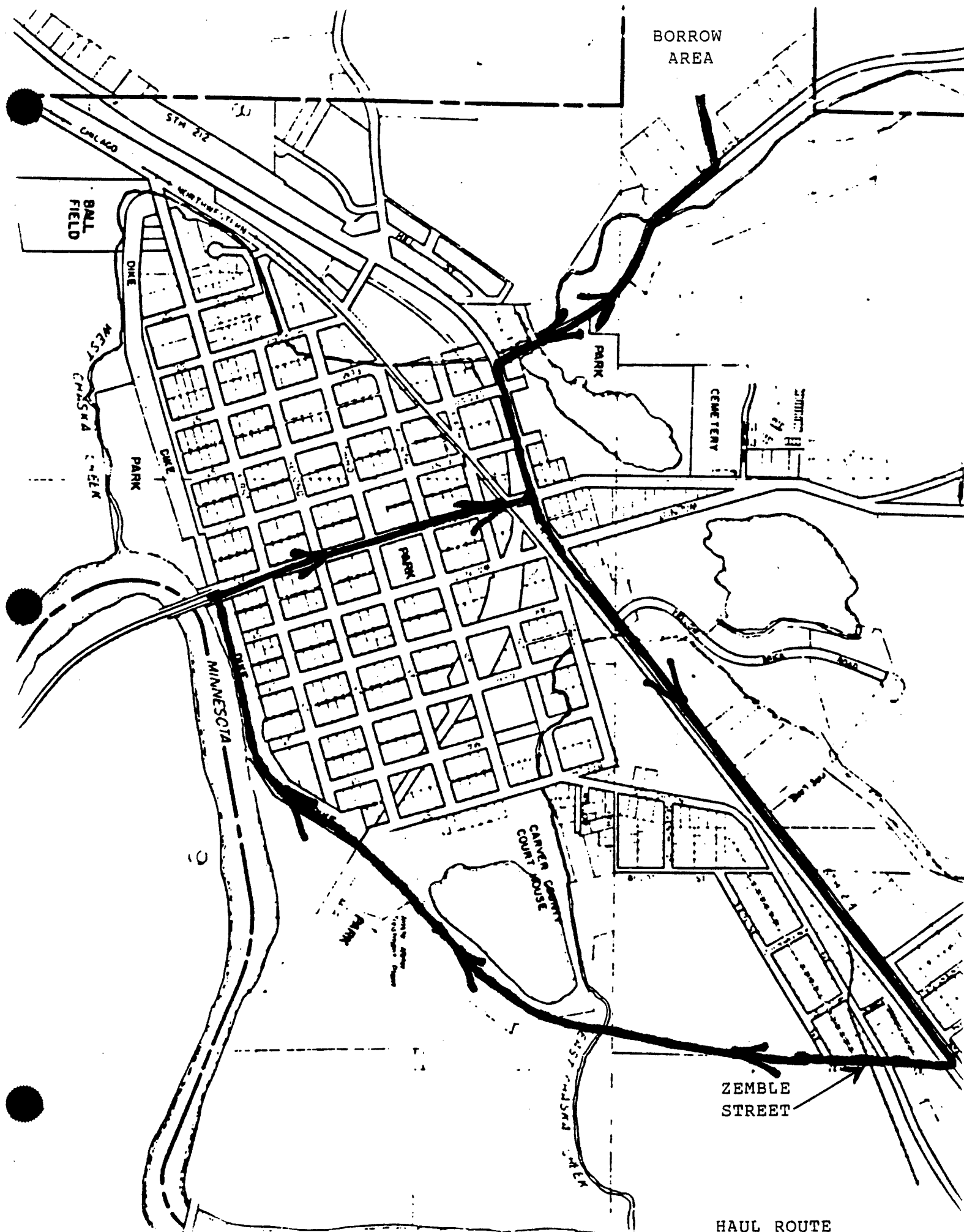
9. Adequate supplies of riprap, bedding, concrete aggregate and impervious levee fill are available within a reasonable haul distance of Chaska. Additional information on construction materials is presented in Appendix C.

#### DISPOSAL AREA

10. A disposal area for debris and waste is available at the Louisville Landfill, located approximately 3 miles southwest of the project site. This area is a locally operated landfill and is available with charge to the contractor. The contractor will be encouraged to dispose of timber off site for some useful purpose.



HAUL ROUTE  
PLATE F-1



HAUL ROUTE  
PLATE E-2

APPENDIX G

COST ESTIMATE

MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX G

COST ESTIMATE

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MINNESOTA RIVER AT CHASKA, MINNESOTA  
STAGE 4 FEATURE DESIGN MEMORANDUM  
FLOOD CONTROL PROJECT

APPENDIX G

NARRATIVE REPORT  
FOR

CHASKA STAGE 4 DM

COST ESTIMATE

1. Description of Project. The flood control project at Chaska, Minnesota is divided into four stages. This Design Memorandum (DM) presents the design of planning for Stage 4 which in general consists of a levee that protects Chaska from flooding from the Minnesota River. Work for this stage consists of upgrading approximately 4,200-feet of existing levee, 2,800-feet of new levee, one 18,000 GPM pump station, 2 outlets with gatewells, interceptor pipe with manholes and inlets, relief wells, wick drains and sanitary sewer with lift station.
  2. Proposed construction methods for major work items.
    - a. Impervious Fill. Impervious fill will be loaded at borrow pit and hauled by trucks via established haul routes. It is assumed in this estimate that trucks will have to drive on existing levees, dozers, sheepsfoot compactors and water trucks will be used. Impervious fill material price is a separate line item, since this is a non-federal cost.
    - b. Wick Drains. Wick drains will be installed to allow water to move from soil to consolidate soil in a rapid manner. The wick drains will be constructed in the new levee area. A special fabricated mandrel is attached to a hydraulic excavator for installation. Production rates, material costs and crew size were developed by consultation with manufactures representative.
    - c. Outlets. Two outlets will be constructed. They consist of Outlet B upstream of the Highway 41 Bridge. Outlet B consists of a 72-inch and twin 48-inch RCP with gatewell, sluice gate and scour hole. Work consists of cast-in-place concrete, 72"x72" sluice gate, sheetpile, excavation and backfill. The outlet will be constructed using a crane for placing concrete, sluice gate, sheetpile, RCP and other items of work.
- Outlet C will be constructed near Oak Street. This will consist of a 66-inch and twin 48-inch RCP with gatewell, sluice gate and scour hole. Other work consists of excavation, cast-in-place concrete, formwork, and backfill. The outlet will be constructed using a crane for placing concrete, sluice gate, sheetpile, RCP and other items of work.

d. Pump Station. An 18,000 GPM pumping station with three 6,000 GPM pumps will be constructed near Oak Street. Work associated with the pump station is sitework, cast-in-place concrete, trash rack, structural steel, sluice gate, electrical and mechanical. The pump station will be constructed by using a crane and other equipment necessary for the superstructure and parking area.

e. Reinforced Concrete Pipe. Reinforced concrete pipe will be installed between the manholes. 18 inch through 72 inch diameter RCP will be constructed. Excavation was based on a 1-on-2 sideslopes so unit prices are somewhat increased. Reinforced concrete pipe will be constructed with a hydraulic excavator and a crane will be used in addition to the excavator for placing the larger pieces of pipe.

f. Relief Wells. Relief wells will be installed at 36 various locations. The relief wells are 30-inch diameter with plastic screens and 48-inch diameter manholes. Material prices, production rates and equipment are based on quotes from a local well driller contractor.

g. Dewatering. Dewatering will include using wellpoints, sumping, deep wells and sheetpile. Dewatering will be needed for various items of work including the inspection trench, outlets B and C, sewer removal and replacement and miscellaneous structures below the water table.

3. Unit Cost Analysis. The unit costs shown were derived by MCACES composer, work analysis and from production rates obtained from specialty contractors.

4. Planning, Engineering and Design Costs. These costs were obtained by Project Management and were based on actual man-hour estimates derived by all affected functional units.

5. Construction Management Costs. This cost was obtained by the Construction Branch.

6. Contingency Analysis. Contingencies shown on the summary sheets reflect uncertainties in design (quantities), unit pricing and pure unknowns. The range for the contingency component for quantities varied between zero and forty percent and for unit costs varied between zero and ten percent. The pure unknown component was given a constant five percent value and was applied to all work items.

TOTAL - STAGE 4

\*\*\*\* TOTAL PROJECT COST SUMMARIES \*\*\*\*

PROJECT: CHASKA, STAGE 4 (FDM ESTIMATE)

LOCATION: CHASKA, MINNESOTA

DATE PREPARED: 4/15/91

PREPARED BY: CENCS-ED-C

REVIEWED AND APPROVED BY: *Allen Hagan*, CHIEF, ED-C

ACCOUNT NUMBER	ITEM DESCRIPTION	ESTIMATED COST(\$) (EPD)	CONTINGENCY AMOUNT(\$)	%	EST COST (EPD)	OMB INFLATION TO OCT-91	%	EPC OCT-91	MID POINT OF FEATURE	OMB INFLATION (+/-)	INFLATED COST AMOUNT (\$)	INFLATED CONTG. AMT. (\$)	FULLY FUNDED COST
02---	RELOCATIONS	451,000	84,000	19%	535,000	1.90%		545,000	Oct-93	8.68%	499,000	93,000	592,000
11---	LEVEES AND FLOODWALLS	4,699,000	856,000	18%	5,555,000	1.90%		5,661,000	Oct-93	8.68%	5,204,000	948,000	6,152,000
13---	PUMPING PLANT	529,000	106,000	20%	635,000	1.90%		647,000	Oct-93	8.68%	586,000	117,000	703,000
14---	RECREATION FACILITIES	86,000	17,000	20%	103,000	1.90%		105,000	Oct-93	8.68%	95,000	19,000	114,000
-----													
TOTAL CONSTRUCTION COSTS =====>		5,765,000	1,063,000		6,828,000			6,958,000			6,384,000	1,177,000	7,561,000
-----													
01---	LANDS AND DAMAGES	1,565,000	299,000	19%	1,864,000	1.90%		1,899,000	Sep-92	4.20%	1,662,000	317,000	1,979,000
30---	PLANNING, ENGINEERING AND DESIGN	1,607,000	126,000	8%	1,733,000	2.36%		1,774,000	Jan-92	3.00%	1,694,000	133,000	1,827,000
31---	CONSTRUCTION MANAGEMENT	375,000	0	0%	375,000	2.36%		384,000	Oct-93	17.36%	450,000	0	450,000
-----													
TOTAL PROJECT COSTS =====>		9,312,000	1,488,000		10,800,000			11,015,000			10,190,000	1,627,000	11,817,000



ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
=====								
01.-.-.-	LANDS AND DAMAGES							
01.B.-.-	POST-AUTHORIZATION PLANNING	LS	1	600	600	100	16.7%	1,2,4
01.D.-.-	ACQUISITION:							
01.D.-.-	ACQUISITION (LOCAL SPONSOR)	OSP	45	611	27,500	4,100	14.9%	1,2,4
01.D.-.-	ACQUISITION (FED.REVIEW/ASSISTANCE)	OSP	45	287	12,900	1,900	14.7%	1,2,4
01.E.-.-	CONDEMNATION (POST-DT FILING):							
01.E.-.-	CONDEMNATION (POST-DT)-LOCAL SPONSOR	TRT	0	0				
01.E.O.E	FEDERAL REVIEW OF DOCUMENTS	TRT	0	0				
01.F.-.-	APPRAISALS:							
01.F.2.H	PREPARE APPRAISALS-LOCAL SPONSOR	OSP	45	500	22,500	3,400	15.1%	1,2,4
01.F.2.J	FEDERAL REVIEW OF APPRAISALS	OSP	45	260	11,700	1,800	15.4%	1,2,4
01.H.-.-	RELOCATIONS:							
01.H.1.-	P.L.91-646 RELOCATIONS-LOCAL SPONSOR	OSP	8	625	5,000	800	16.0%	1,2,4
01.H.1.E	FEDERAL REVIEW OF DOCUMENTS	OSP	8	375	3,000	500	16.7%	1,2,4
01.M.-.-	REAL ESTATE RECEIPTS/PAYMENTS:							
01.M.3.-	LAND PAYMENTS	LS	1	1,293,000	1,293,000	258,600	20.0%	1,2,4
01.M.4.-	P.L.91-646 RELOCATIONS	LS	1	188,250	188,300	28,200	15.0%	1,2,4
Total Estimated Cost					1,565,000			
Contingencies					19.11%	299,000		
Total Estimated Cost and Contingencies						1,864,000		

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
=====								
02.-.-.- RELOCATIONS								
02.1.A.-	MOB.& DEMOB.	JOB	1	16,550.00	16,550	4,000	24.2%	1,2,3
-----								
02.3.A.A	MOB & DEMOB.	JOB	1	16,550.00	16,550	4,000	20.0%	1,2,3
-----								
02.1.2.-	NORTH RAMP	JOB	1	56,975.00	56,975	11,394	20.0%	1,2,3
-----								
02.1.2.B	AGGREGATE BASE	CY	165	11.40	1,881	376	20.0%	1,2,3
02.1.2.B	ROAD FILL -IMPERVIOUS	CY	9,170	4.56	41,815	8,363	20.0%	1,2,3
02.1.2.B	LOADING FROM PIT	CY	9,170	0.57	5,227	1,045	20.0%	1,2,3
02.1.2.B	HAULING FROM PIT	CY	11,004	0.59	6,492	1,298	20.0%	1,2,3
02.1.2.B	TOPSOIL	CY	350	1.93	676	135	20.0%	1,2,3
02.1.2.B	SEEDING	ACR	1	680.00	884	177	20.0%	1,2,3
-----								
02.1.2.-	CEDAR STREET RAMP	EA	1	34,721.00	34,721	6,945	20.0%	1,2,3
-----								
02.1.2.B	AGGREGATE BASE	CY	244	11.40	2,782	556	20.0%	1,2,3
02.1.2.B	ROAD FILL - IMPERVIOUS	CY	5,400	4.56	24,624	4,925	20.0%	1,2,3
02.1.2.B	LOADING FROM PIT	CY	5,400	0.57	3,078	616	20.0%	1,2,3
02.1.2.B	HAULING FROM PIT	CY	5,400	0.71	3,834	767	20.0%	1,2,3
02.1.2.B	TOPSOIL	CY	93	1.93	179	36	20.1%	1,2,3
02.1.2.B	SEEDING	ACR	0	1,120.00	224	45	20.1%	1,2,3
-----								
02.1.2.-	PEDESTRIAN RAMP	JOB	1	27,996.00	27,996	5,599	20.0%	1,2,3
-----								
02.1.2.B	AGGREGATE BASE	CY	39	11.40	445	89	20.0%	1,2,3
02.1.2.B	FILL - IMPERVIOUS	CY	3,200	4.40	14,080	2,816	20.0%	1,2,3
02.1.2.B	LOADING FROM PIT	CY	3,200	0.57	1,824	365	20.0%	1,2,3
02.1.2.B	HAULING FROM PIT	CY	3,200	0.68	2,176	435	20.0%	1,2,3
02.1.2.B	RAILING	LF	210	45.10	9,471	1,894	20.0%	1,2,3
-----								
02.1.2.-	BEECH STREET RAMP	JOB	1	12,098.00	12,098	2,420	20.0%	1,2,3
-----								
02.1.2.B	AGGREGATE BASE COURSE	CY	70	11.40	798	160	20.1%	1,2,3
02.1.2.B	FILL IMPERVIOUS	CY	2,000	4.40	8,800	1,760	20.0%	1,2,3
02.1.2.B	LOAD FROM PIT	CY	2,000	0.57	1,140	228	20.0%	1,2,3
02.1.2.B	HAUL FROM PIT	CY	2,000	0.68	1,360	272	20.0%	1,2,3
-----								
02.1.2	REMOVE PEDESTRAIN BDGE.	SF	300	3.89	1,167	233	20.0%	1,2,3
-----								
02.3.2.B	REMOVE WOOD RAIL	LF	40	1.75	70	14	20.0%	1,2,3
02.3.2.B	REMOVE PLANKING	SF	300	0.94	282	56	19.9%	1,2,3
02.3.2.B	REMOVE SUBSTRUCTURE	JOB	1	815.00	815	163	20.0%	1,2,3
-----								
02.3.2.-	WATER LINES	JOB	1	1,965.00	1,965	393	20.0%	1,2,3
-----								
02.3.2.Q	RELOCATE HYDRANT	EA	5	393.00	1,965	393	20.0%	1,2,3
-----								
02.3.2.-	UTILITY MODIFICATIONS	JOB	1	24,310.00	24,310	12,155	50.0%	1,2,3
-----								
02.3.2.R	REMOVE OVERHEAD LINES	LF	100	37.90	3,790	1,895	50.0%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT	AMOUNT	CONTINGENCIES		
				PRICE		AMOUNT	PERCENT	REASON
=====								
02.3.2.R	REMOVE UTILITY POLE	EA	12	309.00	3,708	1,854	50.0%	1,2,3
02.3.2.R	REPLACE UTILITY POLES	EA	12	425.00	5,100	2,550	50.0%	1,2,3
02.3.2.R	REMOVE UTILITY POLES	EA	4	309.00	1,236	618	50.0%	1,2,3
02.3.2.R	REMOVE UNDERGROUND TELE	LF	50	75.80	3,790	1,895	50.0%	1,2,3
02.3.2.Q	REMOVE HYDRANTS	EA	5	124.00	620	310	50.0%	1,2,3
02.3.2.R	REPLACE HYDRANTS	EA	5	31.60	158	79	50.0%	1,2,3
02.3.2.Q	FILL SANITARY PIPE	CY	85	69.50	5,908	2,954	50.0%	1,2,3
-----								
02.3.2 -	LIFT STATION	JOB	1	44,200.00	44,200	8,840	20.0%	1,2,3
-----								
02.3.2.B	LIFT STATION	EA	1	44,200.00	44,200	8,840	20.0%	1,2,3
-----								
02.3.2 -	INSTALL 12" SANITARY	LF	2,260	63.37	143,212	19,497	13.6%	1,2,3
-----								
02.3.2.B	BACKFILL	CY	16,651	5.01	83,422	8,342	10.0%	1,2,3
02.3.2.Q	12" SANITARY PIPE	LF	2,260	22.90	51,754	10,351	20.0%	1,2,3
02.3.2.B	EXCAVATION	CY	16,741	0.48	8,036	804	10.0%	1,2,3
-----								
02.3.2 -	INSTALL 8" SANITARY	LF	1,490	47.36	70,563	9,456	13.4%	1,2,3
-----								
02.3.2.B	BACKFILL	CY	11,007	3.75	41,276	4,128	10.0%	1,2,3
02.3.2.Q	8" PIPE	LF	1,490	16.10	23,989	4,798	20.0%	1,2,3
02.3.2.B	EXCAVATION	CY	11,037	0.48	5,298	530	10.0%	1,2,3
-----								
02.3.2.-	MANHOLES	JOB	1	17,500.00	17,500	3,094	17.7%	
-----								
02.3.2.B	MANHOLE NO.1	JOB	1	2,970.00	2,970	523	17.6%	1,2,3
02.3.2.B	MANHOLE NO.2	JOB	1	3,130.00	3,130	548	17.5%	1,2,3
02.3.2.B	MANHOLE NO.3	JOB	1	4,290.00	4,290	716	16.7%	1,2,3
02.3.2.B	MANHOLE NO.4	JOB	1	2,410.00	2,410	441	18.3%	1,2,3
02.2.2.B	MANHOLE NO.5	JOB	1	1,780.00	1,780	322	18.1%	1,2,3
02.3.2.B	MANHOLE NO.6	JOB	1	1,570.00	1,570	290	18.5%	1,2,3
02.3.2.B	MANHOLE NO.7	JOB	1	1,350.00	1,350	254	18.8%	1,2,3
-----								
Total Estimated Cost					451,257			
Contingencies					18.62%	84,026		
-----								
Total Estimated Cost and Contingencies						535,283		

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		
						AMOUNT	PERCENT	REASON
=====								
11.-.-.-	LEVEES AND FLOODWALLS							
11.O.A.-	MOB/DEMOB & PREP	JOB	1	44,200.00	44,200	8,840	20.0%	1,2,3
11.O.A.B	MOB./DEMOB. AND PREP.	JOB	1	44,200.00	44,200	8,840	20.0%	1,2,3
11.O.B.-	DEWATERING	JOB	1	379,500.00	379,500	56,925	15.0%	1,2,3
11.O.B.B	DEWATERING	JOB	1	379,500.00	379,500	56,925	15.0%	1,2,3
11.O.1.-	CLEAR AND GRUB	ACR	27	2,350.00	63,450	12,690	20.0%	1,2,3
11.O.1.B	CLEAR AND GRUB	ACR	27	2,350.00	63,450	12,690	20.0%	1,2,3
11.O.1.-	COMMON EXCAVATION	CY	16,632	1.60	26,611	5,322	20.0%	1,2,3
11.O.1.B	COMMON EXCAVATION	CY	16,632	1.60	26,611	5,322	20.0%	1,2,3
11.O.1.-	IMPERVIOUS FILL	CY	271,402	2.80	759,926	151,985	20.0%	1,2,3
11.O.1.B	IMPERVIOUS FILL	CY	271,402	2.80	759,926	151,985	20.0%	1,2,3
11.O.1.-	IMPERVIOUS FILL NON-FED	CY	325,682	0.45	146,557	29,311	20.0%	1,2,3
11.O.1.B	IMPERVIOUS FILL NON-FED	CY	325,682	0.45	146,557	29,311	20.0%	1,2,3
11.O.1.-	STRIPPING	CY	27,470	2.37	65,104	13,021	20.0%	1,2,3
11.O.1.B	STRIPPING	CY	27,470	2.37	65,104	13,021	20.0%	1,2,3
11.O.1.-	INSPECTION TRENCH	LF	7,115	4.70	33,442	6,688	20.0%	1,2,3
11.O.1.B	INSPECTION TRENCH	CY	18,579	1.80	33,442	6,688	20.0%	1,2,3
11.O.1.-	PERVIOUS FILL	CY	20,200	7.62	153,924	30,785	20.0%	1,2,3
11.O.1.B	PERVIOUS FILL	CY	20,200	7.62	153,924	30,785	20.0%	1,2,3
11.O.1.-	RANDOM FILL	CY	1,835	2.84	5,211	1,042	20.0%	1,2,3
11.O.1.B	RANDOM FILL	CY	1,835	2.84	5,211	1,042	20.0%	1,2,3
11.O.1.-	GEOTEXTILE	SY	10,933	1.09	11,917	2,383	20.0%	1,2,3
11.O.1.B	GEOTEXTILE	SY	10,933	1.09	11,917	2,383	20.0%	1,2,3
11.O.1.-	BEDDING	CY	2,733	35.60	97,295	19,459	20.0%	1,2,3
11.O.1.B	BEDDING	CY	2,733	35.60	97,295	19,459	20.0%	1,2,3
11.O.1.-	RIPRAP	CY	5,467	33.60	183,691	36,738	20.0%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT	AMOUNT	CONTINGENCIES		
				PRICE		AMOUNT	PERCENT	REASON
=====								
11.0.1.B	RIPRAP	CY	5,467	33.60	183,691	36,738	20.0%	1,2,3
11.0.1.-	PERVIOUS BERM FILL	CY	18,700	5.94	111,078	22,216	20.0%	1,2,3
11.0.1.B	PERVIOUS FILL BERM	CY	18,700	5.94	111,078	22,216	20.0%	1,2,3
11.0.1.-	PERVIOUS FILL MN. RIVER	CY	4,975	12.20	60,695	12,139	20.0%	1,2,3
11.0.1.B	PERVIOUS FILL	CY	4,975	12.20	60,695	12,139	20.0%	1,2,3
11.0.1.-	TOPSOIL	CY	16,581	3.33	55,215	11,043	20.0%	1,2,3
11.0.1.B	TOPSOIL	CY	16,581	3.33	55,215	11,043	20.0%	1,2,3
11.0.1.-	SEEDING	ACR	30	1,870.00	56,100	11,220	20.0%	1,2,3
11.0.1.B	SEEDING	ACR	30	1,870.00	56,100	11,220	20.0%	1,2,3
11.0.1.-	EAST CREEK, TIE IN	JOB	1	2,900.00	2,900	580	20.0%	1,2,3
11.0.1.B	EXCAVATION AND EMBANKMENT	JOB	1	2,900.00	2,900	580	20.0%	1,2,3
11.0.1-	STRUCTURAL REMOVALS	JOB	1	103,826.00	103,826	25,958	25.0%	1,2,3
11.0.1.B	REMOVE PUMP STATION	EA	2	9,510.00	19,020	4,755	25.0%	1,2,3
11.0.1.B	REMOVE HOUSE FOUNDS.	EA	6	2,290.00	13,740	3,435	25.0%	1,2,3
11.0.1.B	REMOVE GARAGE SLABS	SY	320	3.57	1,142	286	25.0%	1,2,3
11.0.1.B	REMOVE FENCE	LF	50	2.49	125	31	25.0%	1,2,3
11.0.1.B	BITUMINOUS REMOVALS	SY	2,430	3.57	8,675	2,169	25.0%	1,2,3
11.0.1.B	HWY. 41 BRIDGE ABUT.	CY	35	94.10	3,294	824	25.0%	1,2,3
11.0.1.B	REMOVE SANITARY MANHOLE	EA	11	4,260.00	46,860	11,715	25.0%	1,2,3
11.0.1.B	REMOVE 10" PIPE 28+80	LF	50	5.88	294	74	25.0%	1,2,3
11.0.1.B	REMOVE 18"	LF	130	5.36	697	174	25.0%	1,2,3
11.0.1.B	PLUG SANITARY SEWER 8"	EA	7	375.00	2,625	656	25.0%	1,2,3
11.0.1.B	PLUG 4" CIP WATERLINE	EA	6	58.40	350	88	25.0%	1,2,3
11.0.1.B	REMOVE GATE VALVE	EA	1	76.70	77	19	25.0%	1,2,3
11.0.1.B	REMOVE 21" DIP 31+90	LF	80	7.51	601	150	25.0%	1,2,3
11.0.1.B	PLUG 2" STEEL GASMAIN	EA	1	56.40	56	14	25.0%	1,2,3
11.0.1.B	REMOVE STORM SEWERS	JOB	1	6,270.00	6,270	1,568	25.0%	1,2,3
11.0.C.-	GUARD POSTS	EA	12	59.33	712	142	19.9%	1,2,3
11.0.C.B	GUARD POSTS	EA	12	59.33	712	142	19.9%	1,2,3
11.0.C.-	TRAFFIC CONTROL	JOB	1	90,900.00	90,900	13,635	15.0%	1,2,3
11.0.C.B	TRAFFIC CONTROL	JOB	1	90,900.00	90,900	13,635	15.0%	1,2,3
11.0.C.-	AGGREGATE BASE COURSE	CY	1,234	12.00	14,808	2,962	20.0%	1,2,3
11.0.C.B	AGGR. BASE 0+00-9+30	CY	172	12.00	2,064	413	20.0%	1,2,3
11.0.C.B	AGGR. BASE 13+20-55+05	CY	775	12.00	9,300	1,860	20.0%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
11.O.C.B	AGGR. BASE 55+65-71+17	CY	287	12.00	3,444	689	20.0%	1,2,3
11.O.G.B	WICK DRAINS	LF	413,714	0.572	236,504	35,476	15.0%	1,2,3
11.O.G.B	WICK DRAINS	LF	345,000	0.57	196,650	29,498	15.0%	1,2,3
11.O.G.B	EXTRA BERM WICK DRAINS	LF	68,714	0.58	39,854	5,978	15.0%	1,2,3
11.O.G.B	RELIEF WELLS	EA	36	18,898.33	680,340	102,051	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 1	EA	1	7,140.00	7,140	1,071	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 2	EA	1	15,200.00	15,200	2,280	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 3	EA	1	15,400.00	15,400	2,310	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 4	EA	1	15,600.00	15,600	2,340	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 5	EA	1	15,500.00	15,500	2,325	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 6	EA	1	15,300.00	15,300	2,295	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 7	EA	1	15,300.00	15,300	2,295	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 8	EA	1	15,200.00	15,200	2,280	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 9	EA	1	15,300.00	15,300	2,295	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 10	EA	1	15,300.00	15,300	2,295	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 11	EA	1	15,300.00	15,300	2,295	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 12	EA	1	18,100.00	18,100	2,715	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 13	EA	1	18,100.00	18,100	2,715	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 14	EA	1	18,100.00	18,100	2,715	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 15	EA	1	18,100.00	18,100	2,715	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 16	EA	1	18,200.00	18,200	2,730	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 17	EA	1	21,700.00	21,700	3,255	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 18	EA	1	21,700.00	21,700	3,255	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 19	EA	1	21,600.00	21,600	3,240	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 20	EA	1	21,600.00	21,600	3,240	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 21	EA	1	21,600.00	21,600	3,240	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 22	EA	1	21,600.00	21,600	3,240	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 23	EA	1	21,600.00	21,600	3,240	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 24	EA	1	21,500.00	21,500	3,225	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 25	EA	1	21,500.00	21,500	3,225	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 26	EA	1	21,200.00	21,200	3,180	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 27	EA	1	21,200.00	21,200	3,180	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 28	EA	1	21,300.00	21,300	3,195	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 29	EA	1	21,300.00	21,300	3,195	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 30	EA	1	21,500.00	21,500	3,225	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 31	EA	1	21,400.00	21,400	3,210	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 32	EA	1	21,500.00	21,500	3,225	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 33	EA	1	21,400.00	21,400	3,210	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 34	EA	1	21,400.00	21,400	3,210	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 35	EA	1	21,400.00	21,400	3,210	15.0%	1,2,3
11.O.G.B	RELIEF WELL NO. 36	EA	1	21,200.00	21,200	3,180	15.0%	1,2,3
11.O.G.-	REINFORCED CONCRETE PIPE	JOB	1	506,162.00	506,162	92,283	18.2%	1,2,3
11.O.G.B	24" RCP CLASS IV	LF	288	46.50	13,392	2,263	16.9%	1,2,3
11.O.G.B	42" RCP CLASS III	LF	482	142.00	68,444	13,073	19.1%	1,2,3
11.O.G.B	54" RCP CLASS III	LF	394	220.00	86,680	17,180	19.8%	1,2,3
11.O.G.B	60" RCP CLASS III	LF	392	160.00	62,720	11,666	18.6%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
11.O.G.B	66" RCP CLASS III	LF	334	192.00	64,128	11,928	18.6%	1,2,3
11.O.G.B	72" RCP CLASS III	LF	336	189.00	63,504	11,304	17.8%	1,2,3
11.O.G.B	30" RCP CLASS III	LF	198	108.00	21,384	2,887	13.5%	1,2,3
11.O.G.B	30" RCP CLASS III	LF	206	65.00	13,390	2,116	15.8%	1,2,3
11.O.G.B	36" RCP CLASS III	LF	182	77.40	14,087	2,367	16.8%	1,2,3
11.O.G.B	48" RCP CLASS III	LF	154	110.00	16,940	3,049	18.0%	1,2,3
11.O.G.B	48" RCP CLASS III	LF	400	116.00	46,400	8,491	18.3%	1,2,3
11.O.G.B	36" RCP CLASS III	LF	222	72.80	16,162	2,861	17.7%	1,2,3
11.O.G.B	24" RCP CLASS III	LF	250	47.30	11,825	1,975	16.7%	1,2,3
11.O.G.B	18" RCP CLASS III	LF	190	37.40	7,106	1,123	15.8%	1,2,3
11.O.G.-	INLETS	JOB	1	118,770.00	118,770	21,428	18.0%	1,2,3
11.O.G.B	INLET 1A	JOB	1	9,890.00	9,890	1,978	20.0%	1,2,3
11.O.G.B	INLET 2A	JOB	1	6,130.00	6,130	1,085	17.7%	1,2,3
11.O.G.B	INLET 2B	JOB	1	6,270.00	6,270	1,116	17.8%	1,2,3
11.O.G.B	INLET 3A	JOB	1	7,840.00	7,840	1,419	18.1%	1,2,3
11.O.G.B	INLET 4A	JOB	1	8,070.00	8,070	1,461	18.1%	1,2,3
11.O.G.B	INLET 5A	JOB	1	8,690.00	8,690	1,582	18.2%	1,2,3
11.O.G.B	INLET 6A	JOB	1	7,190.00	7,190	1,294	18.0%	1,2,3
11.O.G.B	INLET 7A	JOB	1	6,130.00	6,130	1,091	17.8%	1,2,3
11.O.G.B	INLET 7B	JOB	1	9,180.00	9,180	1,698	18.5%	1,2,3
11.O.G.B	INLET 8A	JOB	1	5,140.00	5,140	905	17.6%	1,2,3
11.O.G.B	INLET 9A	JOB	1	5,140.00	5,140	905	17.6%	1,2,3
11.O.G.B	INLET 10A	JOB	1	13,900.00	13,900	2,377	17.1%	1,2,3
11.O.G.B	INLET 11A	JOB	1	9,030.00	9,030	1,671	18.5%	1,2,3
11.O.G.B	INLET 12A	JOB	1	5,240.00	5,240	922	17.6%	1,2,3
11.O.G.B	INLET 13A	JOB	1	5,390.00	5,390	949	17.6%	1,2,3
11.O.G.B	INLET 13B	JOB	1	5,540.00	5,540	975	17.6%	1,2,3
11.O.G.B	OUTLET B	JOB	1	242,750.00	242,750	45,126	18.6%	1,2,3
11.O.G.B	CONCRETE WALLS	CY	205	85.50	17,528	3,506	20.0%	1,2,3
11.O.G.B	CONCRETE BASE SLAB	CY	15	94.40	1,416	283	20.0%	1,2,3
11.O.G.B	CONCRETE TOP SLAB	CY	2	119.00	179	35	19.8%	1,2,3
11.O.G.B	WALL FORMS	SF	5,726	6.74	38,593	7,719	20.0%	1,2,3
11.O.G.B	BASE SLAB FORMS	SF	89	3.40	303	61	20.1%	1,2,3
11.O.G.B	TOP SLAB FORMS	SF	71	8.99	638	128	20.1%	1,2,3
11.O.G.B	REINFORCING	LBS	29,948	0.49	14,675	2,935	20.0%	1,2,3
11.O.G.B	CURED SURFACE	SF	6,231	0.10	623	125	20.1%	1,2,3
11.O.G.B	FINISHED SURFACE	SF	346	0.71	246	49	19.9%	1,2,3
11.O.G.B	LADDERS	LBS	447	4.03	1,801	360	20.0%	1,2,3
11.O.G.B	PLATFORMS	LBS	241	1.09	263	53	20.2%	1,2,3
11.O.G.B	HANDRAIL	LBS	1,114	4.05	4,512	902	20.0%	1,2,3
11.O.G.B	STEEL GRATING	LBS	746	1.09	813	163	20.0%	1,2,3
11.O.G.B	DIAMOND STEEL PANELS	LBS	408	1.69	690	138	20.0%	1,2,3
11.O.G.B	BULKHEAD	LBS	3,000	1.05	3,150	630	20.0%	1,2,3
11.O.G.B	SLUICEGATE 72" X 72"	EA	1	32,400.00	32,400	6,480	20.0%	1,2,3
11.O.G.B	72" RCP 6000D	LF	37	383.00	14,171	2,834	20.0%	1,2,3
11.O.G.B	72" RCP 5000D	LF	53	350.00	18,550	3,710	20.0%	1,2,3
11.O.G.B	48" RCP 6000D	LF	86	212.00	18,232	3,646	20.0%	1,2,3
11.O.G.B	48" RCP 5000D	LF	118	177.00	20,886	4,177	20.0%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
11.O.G.B	48" RCP CLASS 5 TIED	LF	38	161.00	6,118	1,224	20.0%	1,2,3
11.O.G.B	48" RCP END SECTION	EA	2	912.00	1,824	365	20.0%	1,2,3
11.O.G.B	EXCAVATION PIPES	CY	11,261	0.90	10,135	1,014	10.0%	1,2,3
11.O.G.B	BACKFILL	CY	11,038	2.14	23,621	2,362	10.0%	1,2,3
11.O.G.B	SHEETPILE PZ 27	SF	384	12.70	4,877	975	20.0%	1,2,3
11.O.G.B	RIPRAP @ SCOUR HOLE	CY	116	35.60	4,130	826	20.0%	1,2,3
11.O.G.B	BEDDING @ SCOUR HOLE	CY	58	32.50	1,885	377	20.0%	1,2,3
11.O.G.B	EXCAVATION @ SCOUR HOLE	CY	252	1.95	491	49	10.0%	1,2,3
11.O.G.B	OUTLET C	JOB	1	238,021.00	238,021	43,141	18.1%	1,2,3
11.O.G.B	CONCRETE WALLS	CY	205	85.50	17,528	3,506	20.0%	1,2,3
11.O.G.B	BASE SLAB CONCRETE	CY	15	94.40	1,416	283	20.0%	1,2,3
11.O.G.B	TOP SLAB CONCRETE	CY	3	95.40	267	53	19.9%	1,2,3
11.O.G.B	WALL FORMS	SF	5,757	6.74	38,802	7,760	20.0%	1,2,3
11.O.G.B	BASE SLAB FORMS	SF	89	3.40	303	61	20.1%	1,2,3
11.O.G.B	TOP SLAB FORMS	SF	40	9.00	360	72	20.0%	1,2,3
11.O.G.B	REINFORCING	LBS	30,124	0.49	14,761	2,952	20.0%	1,2,3
11.O.G.B	FINISHED SURFACE	SF	314	0.71	223	45	20.2%	1,2,3
11.O.G.B	CURING COMPOUND	SF	6,200	0.10	620	124	20.0%	1,2,3
11.O.G.B	LADDERS	LBS	447	4.03	1,801	360	20.0%	1,2,3
11.O.G.B	PLATFORMS	LBS	241	1.09	263	53	20.2%	1,2,3
11.O.G.B	HANDRAIL	LBS	1,114	4.05	4,512	902	20.0%	1,2,3
11.O.G.B	STEEL GRATING	LBS	747	1.09	814	163	20.0%	1,2,3
11.O.G.B	STEEL PANELS	LBS	899	0.77	692	138	19.9%	1,2,3
11.O.G.B	BULKHEAD	LBS	3,000	1.05	3,150	630	20.0%	1,2,3
11.O.G.B	SLUICEGATE 72" X 72"	JOB	1	32,400.00	32,400	6,480	20.0%	1,2,3
11.O.G.B	66" RCP 6000D	LF	35	312.00	10,920	2,184	20.0%	1,2,3
11.O.G.B	66" RCP 5000D	LF	52	286.00	14,872	2,974	20.0%	1,2,3
11.O.G.B	66" CLASS V	LF	7	230.00	1,495	299	20.0%	1,2,3
11.O.G.B	48" 6000D	LF	63	212.00	13,356	2,671	20.0%	1,2,3
11.O.G.B	48" 5000D	LF	118	177.00	20,886	4,177	20.0%	1,2,3
11.O.G.B	48" TIED CLASS V	LF	38	161.00	6,118	1,224	20.0%	1,2,3
11.O.G.B	48" END SECTION	EA	2	912.00	1,824	365	20.0%	1,2,3
11.O.G.B	EXCAVATION PIPES	CY	8,680	0.90	7,812	781	10.0%	1,2,3
11.O.G.B	BACKFILL PIPES	CY	8,486	4.28	36,320	3,632	10.0%	1,2,3
11.O.G.B	RIPRAP @ SCOUR HOLE	CY	116	35.60	4,130	826	20.0%	1,2,3
11.O.G.B	BEDDING @ SCOUR HOLE	CY	58	32.50	1,885	377	20.0%	1,2,3
11.O.G.B	EXCAVATION SCOUR HOLE	CY	252	1.95	491	49	10.0%	1,2,3
11.O.G.B	MANHOLE 1	JOB	1	3,391.00	3,391	678	20.0%	1,2,3
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTMENT RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	48" RISER	LF	10	126.00	1,222	244	20.0%	1,2,3
11.O.G.B	BASE SLAB	EA	1	243.00	243	49	20.2%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	0	460.00	74	15	20.3%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 2	JOB	1	8,028.00	8,028	1,605	20.0%	1,2,3



ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT	AMOUNT	CONTINGENCIES		
				PRICE		AMOUNT	PERCENT	REASON
=====								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTMENT RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	48" RISER	LF	5	101.00	467	93	19.9%	1,2,3
11.O.G.B	PRECAST TEE 54" X 48"	EA	1	1,550.00	1,550	310	20.0%	1,2,3
11.O.G.B	ARCH CONCRETE	CY	25	83.50	2,088	418	20.0%	1,2,3
11.O.G.B	ARCH FORMS	SF	264	5.47	1,444	289	20.0%	1,2,3
11.O.G.B	ARCH REINFORCING	LBS	1,280	0.49	627	125	19.9%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
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11.O.G.B	MANHOLE 3	JOB	1	7,459.00	7,459	1,491	20.0%	1,2,3
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11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTMENT RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	48" RISER	LF	5	205.00	947	189	20.0%	1,2,3
11.O.G.B	PRECAST TEE 60" X48"	EA	1	2,090.00	2,090	418	20.0%	1,2,3
11.O.G.B	ARCH CONCRETE	CY	14	83.50	1,169	234	20.0%	1,2,3
11.O.G.B	ARCH FORMS	SF	192	5.47	1,050	210	20.0%	1,2,3
11.O.G.B	ARCH REINFORCING	LBS	716	0.49	351	70	19.9%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
-----								
11.O.G.B	MANHOLE 4	JOB	1	7,547.00	7,547	1,509	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTMENT RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	6	155.00	946	189	20.0%	1,2,3
11.O.G.B	PRECAST TEE 66" X 48"	EA	1	2,090.00	2,090	418	20.0%	1,2,3
11.O.G.B	ARCH CONCRETE	CY	15	83.50	1,253	251	20.0%	1,2,3
11.O.G.B	ARCH FORMS	SF	212	4.96	1,052	210	20.0%	1,2,3
11.O.G.B	ARCH REINFORCING	LBS	770	0.46	354	71	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
-----								
11.O.G.B	MANHOLE 5	JOB	1	5,512.00	5,512	1,102	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTMENT RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	EA	1	1,190.00	1,190	238	20.0%	1,2,3
11.O.G.B	PRECAST TEE 72" X 48"	EA	1	2,470.00	2,470	494	20.0%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
-----								
11.O.G.B	MANHOLE 6	JOB	1	21,421.00	21,421	4,284	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTMENT RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	10	126.00	1,260	252	20.0%	1,2,3
11.O.G.B	TOP SLAB CONCRETE	CY	5	97.90	490	98	20.0%	1,2,3
11.O.G.B	WALL CONCRETE	CY	14	685.00	9,590	1,918	20.0%	1,2,3
11.O.G.B	BASE SLAB CONCRETE	CY	4	87.40	315	63	20.0%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
11.O.G.B	TOP SLAB FORMS	SF	91	8.99	818	164	20.0%	1,2,3
11.O.G.B	WALL FORMS	SF	775	6.74	5,224	1,045	20.0%	1,2,3
11.O.G.B	BASE SLAB FORMS	SF	33	3.40	112	22	19.6%	1,2,3
11.O.G.B	REINFORCING	LBS	2,420	0.49	1,186	237	20.0%	1,2,3
11.O.G.B	FINISH AREA	SF	235	0.71	167	33	19.8%	1,2,3
11.O.G.B	CURING COMPOUND	SF	1,130	0.10	113	23	20.4%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	2	147.00	294	59	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 7	JOB	1	5,386.00	5,386	1,077	20.0%	1,2,3
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	7	126.00	819	164	20.0%	1,2,3
11.O.G.B	MIDDLE SLAB 72" X 8"	EA	1	325.00	325	65	20.0%	1,2,3
11.O.G.B	BARREL 60"	LF	5	316.00	1,580	316	20.0%	1,2,3
11.O.G.B	BASE SLAB 92" X 8"	EA	1	516.00	516	103	20.0%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	0	736.00	294	59	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 8	JOB	1	5,489.00	5,489	1,098	20.0%	1,2,3
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	7	126.00	819	164	20.0%	1,2,3
11.O.G.B	MIDDLE SLAB 72" X 8"	EA	1	404.00	404	81	20.0%	1,2,3
11.O.G.B	BARRELL 60"	LF	5	215.00	1,075	215	20.0%	1,2,3
11.O.G.B	BASE SLAB 120" X 8"	EA	1	879.00	879	176	20.0%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	1	575.00	460	92	20.0%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 9	EA	1	6,983.00	6,983	1,395	20.0%	1,2,3
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48" X 6"	LF	7	177.00	1,186	237	20.0%	1,2,3
11.O.G.B	PRECAST TEE 48" X 48"	EA	1	1,620.00	1,620	324	20.0%	1,2,3
11.O.G.B	ARCH CONCRETE	CY	13	86.70	1,127	225	20.0%	1,2,3
11.O.G.B	ARCH FORMS	SF	161	5.47	881	176	20.0%	1,2,3
11.O.G.B	ARCH REINFORCING	LBS	646	0.49	317	63	19.9%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 10	JOB	1	11,776.00	11,776	2,355	20.0%	1,2,3
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 8"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 72"	EA	1	2,030.00	2,030	406	20.0%	1,2,3
11.O.G.B	CONCRETE TOP SLAB	CY	4	91.30	356	71	19.9%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		
						AMOUNT	PERCENT	REASON
=====								
11.O.G.B	CONCRETE WALLS	CY	8	89.40	751	150	20.0%	1,2,3
11.O.G.B	CONCRETE BASE SLAB	CY	10	82.60	826	165	20.0%	1,2,3
11.O.G.B	FORMS TOP SLAB	SF	74	8.99	665	133	20.0%	1,2,3
11.O.G.B	FORMS WALLS	SF	485	6.74	3,269	654	20.0%	1,2,3
11.O.G.B	FORMS BASE SLAB	SF	71	3.40	241	48	19.9%	1,2,3
11.O.G.B	REINFORCING	LBS	2,420	0.49	1,186	237	20.0%	1,2,3
11.O.G.B	FINISHED AREA	SF	209	0.71	148	30	20.3%	1,2,3
11.O.G.B	CURING COMPOUND	SF	837	0.10	84	17	20.2%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	1	263.00	368	74	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 11	JOB	1	4,907.00	4,907	980	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	5	114.00	616	123	20.0%	1,2,3
11.O.G.B	PRECAST TEE 48" X 48"	EA	1	114.00	114	23	20.2%	1,2,3
11.O.G.B	ARCH CONCRETE	CY	13	86.70	1,127	225	20.0%	1,2,3
11.O.G.B	ARCH FORMS	SF	161	5.47	881	176	20.0%	1,2,3
11.O.G.B	REINFORCING	LBS	646	0.49	317	63	19.9%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 12	JOB	1	4,602.00	4,602	921	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	4	114.00	479	96	20.0%	1,2,3
11.O.G.B	MIDDLE SLAB 72" X 8"	EA	1	294.00	294	59	20.1%	1,2,3
11.O.G.B	BARELL 60"	LF	5	146.00	730	146	20.0%	1,2,3
11.O.G.B	BASE SLAB 120" X 8"	EA	1	879.00	879	176	20.0%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	1	409.00	368	74	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 13	JOB	1	3,819.00	3,819	763	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	9	104.00	962	192	20.0%	1,2,3
11.O.G.B	BASE SLAB 100" X 8"	EA	1	636.00	636	127	20.0%	1,2,3
11.O.G.B	LEAN CONCRETE	CY	0	1,230.00	369	74	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.G.B	MANHOLE 14	JOB	1	3,965.00	3,965	793	20.0%	1,2,3
-----								
11.O.G.B	CASTING	EA	1	220.00	220	44	20.0%	1,2,3
11.O.G.B	ADJUSTING RINGS	EA	2	32.80	66	13	19.7%	1,2,3
11.O.G.B	TOP SLAB 48" X 6"	EA	1	226.00	226	45	19.9%	1,2,3
11.O.G.B	RISER 48"	LF	11	114.00	1,197	239	20.0%	1,2,3
11.O.G.B	BASE SLAB 92" X 8"	EA	1	548.00	548	110	20.1%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
11.O.G.B	LEAN CONCRETE	CY	0	3,680.00	368	74	20.1%	1,2,3
11.O.G.B	GUARD POSTS	EA	5	268.00	1,340	268	20.0%	1,2,3
11.O.R.B	LANDSCAPING	JOB	1	107,150.00	107,150	21,430	20.0%	1,2,3
11.O.C.B	LANDSCAPING TREES	EA	350	233.00	81,550	16,310	20.0%	1,2,3
11.O.C.B	LANDSCAPING SHRUBS	EA	1,000	25.60	25,600	5,120	20.0%	1,2,3
11.O.R.B	POND MARKERS	EA	10	178.00	1,780	356	20.0%	1,2,3
11.O.R.B	POND MARKERS	EA	10	178.00	1,780	356	20.0%	1,2,3
Total Estimated Cost					4,698,824			
Contingencies					18.23%	856,426		
Total Estimated Cost and Contingencies					5,555,250			

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
=====								
13.-.-.-	PUMPING PLANT							
13.0.A.-	MOB/DEMOb & PREP	EA	1	18,900.00	18,900	3,780	20.0%	1,2,3
13.0.A.B	MOB AND DEMOb & PREP	JOB	1	18,900.00	18,900	3,780	20.0%	1,2,3
13.0.D.-	SITWORK	JOB	1	13,261.00	13,261	2,652	20.0%	1,2,3
13.0.D.B	AGGREGATE BASE COURSE	CY	27	19.70	532	106	19.9%	1,2,3
13.0.D.B	BINDER COURSE	SY	373	4.95	1,846	369	20.0%	1,2,3
13.0.D.B	TACK COAT	SY	373	0.03	11	2	18.2%	1,2,3
13.0.D.B	WEAR COURSE	SY	373	5.78	2,156	431	20.0%	1,2,3
13.0.D.B	STRIPING	LF	100	0.14	14	3	21.4%	1,2,3
13.0.D.B	SIDEWALK	SY	13	26.90	358	72	20.1%	1,2,3
13.0.D.B	EXCAVATION	CY	3,177	1.67	5,306	1,061	20.0%	1,2,3
13.0.D.B	BACKFILL	CY	2,247	0.69	1,550	310	20.0%	1,2,3
13.0.D.B	SPOIL TO DISPOSAL	CY	930	1.60	1,488	298	20.0%	1,2,3
13.0.1.-	SUBSTRUCTURE	JOB	1	99,042.00	99,042	19,808	20.0%	1,2,3
13.0.1.C	CONCRETE WALLS	CY	193	87.50	16,888	3,378	20.0%	1,2,3
13.0.1.C	CONCRETE BASE SLAB	CY	107	87.50	9,363	1,873	20.0%	1,2,3
13.0.1.C	CONCRETE TOP SLAB	CY	36	65.20	2,347	469	20.0%	1,2,3
13.0.1.C	WALL FORMS	SF	5,746	5.96	34,246	6,849	20.0%	1,2,3
13.0.1.C	BASE SLAB FORMS	SF	310	3.40	1,054	211	20.0%	1,2,3
13.0.1.C	TOP SLAB FORMS	SF	529	5.47	2,894	579	20.0%	1,2,3
13.0.1.C	REINFORCING	LBS	36,839	0.49	18,051	3,610	20.0%	1,2,3
13.0.1.C	FINISHED SURFACE	SF	1,888	0.71	1,340	268	20.0%	1,2,3
13.0.1.C	CURING COMPOUND	SF	8,474	0.10	847	169	20.0%	1,2,3
13.0.1.E	LADDERS	LBS	497	1.02	507	101	19.9%	1,2,3
13.0.1.E	PLATFORM	LBS	344	1.10	378	76	20.1%	1,2,3
13.0.1.E	HANDRAIL	LBS	156	14.40	2,246	449	20.0%	1,2,3
13.0.1.E	STEEL GRATING	LBS	1,020	0.50	510	102	20.0%	1,2,3
13.0.1.E	DIAMOND STEEL PANELS	LBS	255	0.71	181	36	19.9%	1,2,3
13.0.1.E	TRASH RACK	LBS	4,587	1.05	4,816	963	20.0%	1,2,3
13.0.1.B	RAIL, BEAMS & SUPPORTS	LBS	1,377	2.45	3,374	675	20.0%	1,2,3
13.0.4.-	GATES AND VALVES	EA	3	36,600.00	109,800	21,960	20.0%	1,2,3
13.0.4.0	SLUICE GATE 48" X 48"	EA	3	36,600.00	109,800	21,960	20.0%	1,2,3
13.0.2.-	SUPERSTRUCTURE	JOB	1	15,402.00	15,402	3,080	20.0%	1,2,3
13.0.2.C	CONCRETE WALLS	CY	46	91.70	4,172	834	20.0%	1,2,3
13.0.2.C	WALL FORMS	SF	1,229	6.11	7,509	1,502	20.0%	1,2,3
13.0.2.C	REINFORCING	LBS	5,005	0.49	2,452	490	20.0%	1,2,3
13.0.2.C	FINISHED SURFACE	SF	105	0.71	75	15	20.0%	1,2,3
13.0.2.C	CURING COMPOUND	SF	1,334	0.10	133	27	20.3%	1,2,3
13.0.2.C	CONCRETE STAIRS	CY	1	884.00	1,061	212	20.0%	1,2,3
13.0.2.-	THERMAL AND MOISTURE	JOB	1	14,424.00	14,424	2,883	20.0%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT	AMOUNT	CONTINGENCIES		
				PRICE		AMOUNT	PERCENT	REASON
=====								
13.0.2.G	GLU LAN 4" X 12"	LF	70	3.82	267	53	19.9%	1,2,3
13.0.2.G	2" X 12" WALL NAILER	LF	114	2.96	337	67	19.9%	1,2,3
13.0.2.G	FASTENING PLATES	EA	14	412.00	5,768	1,154	20.0%	1,2,3
13.0.2.G	GLU LAM DECK	SF	770	1.59	1,224	245	20.0%	1,2,3
13.0.2.G	BLDG. PAPER	SF	770	0.10	77	15	19.5%	1,2,3
13.0.2.G	ROOFING FELT 30#	SF	770	0.10	77	15	19.5%	1,2,3
13.0.2.G	STAND SEAM METAL ROOF	SF	770	5.48	4,220	844	20.0%	1,2,3
13.0.2.G	FLASHING METAL	SF	150	5.48	822	164	20.0%	1,2,3
13.0.2.G	WOOD TRIM 1 X 12	LF	110	2.96	326	65	19.9%	1,2,3
13.0.2.G	FACIA STRIPS 3.5 "	LF	220	3.82	840	168	20.0%	1,2,3
13.0.2.G	ROOF EDGE 1 X 4	LF	122	3.82	466	93	20.0%	1,2,3
=====								
13.0.2.-	DOORS AND WINDOWS	JOB	1	7,635.00	7,635	1,525	20.0%	1,2,3
=====								
13.0.2.H	WINDOW 2' X 4' ENAM ALU	EA	2	640.00	1,280	256	20.0%	1,2,3
13.0.2.H	WINDOW 2' X 2' ENAM ALM	EA	1	520.00	520	104	20.0%	1,2,3
13.0.2.H	LOUVERS	EA	2	277.00	554	111	20.0%	1,2,3
13.0.2.B	LOUVERS	EA	2	493.00	986	197	20.0%	1,2,3
13.0.2.H	HANDRAIL 1/14"	LF	10	45.10	451	90	20.0%	1,2,3
13.0.2.H	3" PIPE	LF	12	41.40	497	99	19.9%	1,2,3
13.0.2.H	3" CHANNEL	LF	24	4.35	104	21	20.2%	1,2,3
13.0.2.H	1/2" STEEL BAR	LF	75	2.65	199	40	20.1%	1,2,3
13.0.2.G	1" STEEL BAR	LF	28	10.60	297	59	19.9%	1,2,3
13.0.2.H	DOOR FRAME 6'4" X 10'2"	EA	1	667.00	667	133	19.9%	1,2,3
13.0.2.H	DBL. DOOR 6' X 10'2"	EA	1	1,250.00	1,250	250	20.0%	1,2,3
13.0.2.H	PAIR BUTTS	EA	4	68.10	272	54	19.9%	1,2,3
13.0.2.H	THRESHOLD	EA	1	256.00	256	51	19.9%	1,2,3
13.0.2.B	DEAD BOLT	EA	1	302.00	302	60	19.9%	1,2,3
=====								
13.0.2.-	MASONRY	JOB	1	19,065.00	19,065	3,814	20.0%	1,2,3
=====								
13.0.2.D	FACE BRICK	SF	1,753	7.58	13,288	2,658	20.0%	1,2,3
13.0.2.D	COPING STONE	LF	51	40.60	2,071	414	20.0%	1,2,3
13.0.2.D	RELIEF ANGLES	LF	186	19.10	3,553	711	20.0%	1,2,3
13.0.2.D	BRICK ARCH	LF	32	4.79	153	31	20.3%	1,2,3
=====								
13.0.2.-	FINISHES	SF	574	0.65	373	75	20.1%	1,2,3
=====								
13.0.2.J	PAINTING	SF	574	0.65	373	75	20.1%	1,2,3
=====								
13.0.3.-	ELECTRICAL	JOB	1	84,177.00	84,177	16,834	20.0%	1,2,3
=====								
13.0.6.R	TRANSFORMER PAD	EA	1	231.00	231	46	19.9%	1,2,3
13.0.6.R	TRENCH	LF	50	0.50	25	5	20.0%	1,2,3
13.0.6.R	CONDUIT RIGID STEEL 3"	LF	100	6.88	688	138	20.1%	1,2,3
13.0.6.R	CONDUIT 3" ELBOW	EA	4	41.80	167	33	19.8%	1,2,3
13.0.6.R	GROUNDING BUSHING 3"	EA	4	13.40	54	11	20.4%	1,2,3
13.0.6.R	WIRE 500 MCM	LF	500	0.35	175	35	20.0%	1,2,3
13.0.6.R	CABLE TERMINATIONS	EA	8	66.80	534	107	20.0%	1,2,3
13.0.2.R	GROUNDING CONDUCTOR	LF	100	1.57	157	31	19.7%	1,2,3
13.0.3.R	SERVICE SECTION 800 AMP	EA	1	1,170.00	1,170	234	20.0%	1,2,3
13.0.3.R	LIGHTING ARRESTOR	EA	1	442.00	442	88	19.9%	1,2,3

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
13.0.3.R	MAIN CIRC.BRKER.800 AMP	EA	1	2,840.00	2,840	568	20.0%	1,2,3
13.0.3.R	MAIN CONTROL SECTION	EA	5	1,140.00	5,700	1,140	20.0%	1,2,3
13.0.3.R	MOTOR STARTERS	EA	3	9,850.00	29,550	5,910	20.0%	1,2,3
13.0.3.R	MOTOR STARTER SIZE 0	EA	1	360.00	360	72	20.0%	1,2,3
13.0.3.R	CIRCUIT BREAKER 20 AMP	EA	5	329.00	1,645	329	20.0%	1,2,3
13.0.3.R	CONTROL RELAY	EA	16	71.70	1,147	229	20.0%	1,2,3
13.0.3.R	TIMING RELAY	EA	8	174.00	1,392	278	20.0%	1,2,3
13.0.3.R	CONTROL TRANSFORMER	EA	1	37,900.00	37,900	7,580	20.0%	1,2,3
13.0.3.-	MECHANICAL	JOB	1	147,219.00	147,219	29,444	20.0%	1,2,3
13.0.3.Q	PUMPS 100 HP	EA	3	33,600.00	100,800	20,160	20.0%	1,2,3
13.0.3.Q	DISCHARGE PIPE 14" DIP	LF	320	56.90	18,208	3,642	20.0%	1,2,3
13.0.3.Q	FLAP GATES 14"	EA	3	3,790.00	11,370	2,274	20.0%	1,2,3
13.0.3.Q	PUMP HOIST 2 TON 10FPM	EA	1	9,340.00	9,340	1,868	20.0%	1,2,3
13.0.3.Q	SUMP PUMP 150 GPM	EA	1	3,080.00	3,080	616	20.0%	1,2,3
13.0.3.Q	UNIT HEATER 5KW	EA	2	334.00	668	134	20.1%	1,2,3
13.0.3.Q	GATE OPERATOR	EA	1	2,690.00	2,690	538	20.0%	1,2,3
13.0.3.Q	SUMP VENT FAN 1/3 HP	EA	2	130.00	260	52	20.0%	1,2,3
13.0.3.Q	SUMP VENT ROUND DUCT 8"	LF	40	8.40	336	67	19.9%	1,2,3
13.0.3.Q	FAN 1 HP	EA	1	467.00	467	93	19.9%	1,2,3
Total Estimated Cost					529,298			
Contingencies				20.00%		105,855		
Total Estimated Cost and Contingencies						635,153		

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT	AMOUNT	CONTINGENCIES		
				PRICE		AMOUNT	PERCENT	REASON
=====								
14.-.- RECREATION FACILITIES								
14.0.A.-	MOBILIZATION AND PREP	JOB	1	6,310.00	6,310	1,262	20.0%	1,2,3
14.0.A.1	MOBILIZATION & PREP	JOB	1	6,310.00	6,310	1,262	20.0%	1,2,3
14.0.3.-	RECR.PATH, 28+80-55+05	SY	2,333	5.86	13,671	2,734	20.0%	1,2,3
14.0.3.B	BITUMINOUS BIKE PATH	SY	2,333	5.86	13,671	2,734	20.0%	1,2,3
14.0.3.-	RECR.PATH,55+65-71+17	SY	1,380	5.91	8,156	1,631	20.0%	1,2,3
14.0.3.B	BITUMINOUS BIKE PATH	SY	1,380	5.91	8,156	1,631	20.0%	1,2,3
14.0.3.-	RECR.PATH COURTHOUSE LK	SY	3,511	5.78	20,294	4,059	20.0%	1,2,3
14.0.3.B	BITUMINOUS COURTHOUSE	SY	3,511	5.78	20,294	4,059	20.0%	1,2,3
14.0.3.-	LEVEE TRAIL COURTHOUSE	CY	585	12.00	7,020	1,404	20.0%	1,2,3
14.0.3.B	AGGREGATE BASE COURSE	CY	585	12.00	7,020	1,404	20.0%	1,2,3
14.0.3.-	STRIPPING	CY	732	2.85	2,083	417	20.0%	1,2,3
14.0.3.B	STRIPPING	CY	732	1.37	1,003	201	20.0%	1,2,3
14.0.3.B	HAUL TOPSOIL OFFSITE	CY	500	2.16	1,080	216	20.0%	1,2,3
14.0.3.-	TOPSOIL	EA	98	1.93	189	38	20.1%	1,2,3
14.0.3.B	TOPSOIL	CY	98	1.93	189	38	20.1%	1,2,3
14.0.3.-	SEEDING	ACR	0	10,100.00	2,020	404	20.0%	1,2,3
14.0.3.B	SEEDING	ACR	0	10,100.00	2,020	404	20.0%	1,2,3
14.0.3.-	KIOSKS	EA	3	1,657.33	4,972	996	20.0%	1,2,3
14.0.3.F	TIMBER POSTS	EA	9	38.40	346	69	19.9%	1,2,3
14.0.3.F	ROUGH SAWN VERTICALS	EA	102	4.39	448	90	20.1%	1,2,3
14.0.3.F	ROOF JOISTS	EA	30	16.70	501	100	20.0%	1,2,3
14.0.3.F	PANEL RAILS	EA	27	4.23	114	23	20.2%	1,2,3
14.0.3.F	ROOF FASICIA	EA	9	15.90	143	29	20.3%	1,2,3
14.0.3.F	STEEL PLATES	EA	45	18.50	833	167	20.0%	1,2,3
14.0.3.F	POST ANCHORS	EA	9	58.70	528	106	20.1%	1,2,3
14.0.3.F	CONCRETE	CY	2	170.00	340	68	20.0%	1,2,3
14.0.3.F	SIGNS	EA	3	573.00	1,719	344	20.0%	1,2,3
14.0.3.-	RECREATION TRAIL RAMP	JOB	1	21,540.00	21,540	4,308	20.0%	1,2,3
14.0.3.B	AGGREGATE BASE COURSE	CY	83	19.70	1,635	327	20.0%	1,2,3
14.0.3.B	IMPERVIOUS FILL	CY	2,500	4.33	10,825	2,165	20.0%	1,2,3
14.0.3.B	LOAD AT KUSKE PIT	CY	2,500	0.57	1,425	285	20.0%	1,2,3



ED-C(MP)

CHASKA, STAGE 4 - FDM

4/15/91

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
14.0.3.B	HAUL FROM KUSKE PIT	CY	2,500	2.16	5,400	1,080	20.0%	1,2,3
14.0.3.B	BRIDGE RAILING	LF	50	45.10	2,255	451	20.0%	1,2,3
Total Estimated Cost					86,255			
Total Contingencies				20.00%		17,253		
Total Estimated Cost plus Contingencies						103,508		

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES		REASON
						AMOUNT	PERCENT	
=====								
30.-.-.- PLANNING, ENGINEERING AND DESIGN								
30.B.-.-	ENGINEERING AND DESIGN PRIOR TO 5/91	LS	1	808,100	SEE NOTE 1.	0		
30.E.-.-	GENERAL DESIGN MEMORANDUM	LS	1	165,000	165,000	0		5
30.G.-.-	FEATURE DESIGN MEMORANDUM							
30.G.-.-	ED-EG	LS	1	15,000	15,000	300	2.0%	6
30.G.-.-	ED-EF	LS	1	40,600	40,600	400	1.0%	6
30.G.-.-	ED-EJ	LS	1	82,300	82,300	800	1.0%	6
30.G.-.-	ED-ES	LS	1	62,900	62,900	600	1.0%	6
30.G.-.-	ED-ER	LS	1	43,700	43,700	400	1.0%	6
30.G.-.-	ED-EN	LS	1	47,500	47,500	500	1.0%	6
30.G.-.-	ED-FB	LS	1	91,400	91,400	300	0.3%	6
30.G.-.-	ED-FD	LS	1	141,700	141,700	1,200	0.9%	6
30.G.-.-	ED-FE	LS	1	80,300	80,300	700	0.9%	6
30.G.-.-	ED-FF	LS	1	13,900	13,900	100	0.7%	6
30.G.-.-	PD-GC	LS	1	1,100	1,100	100	9.0%	6
30.G.-.-	PD-GL	LS	1	7,200	7,200	100	1.4%	6
30.G.-.-	PD-GM	LS	1	15,500	15,500	400	2.6%	6
30.H.-.-	PLANS AND SPECIFICATIONS							
30.H.-.-	DESIGN BY AE CONTRACT	LS	1	390,000	390,000	58,000	14.9%	6
30.H.-.-	AE CONTRACT ADMINISTRATION							
30.H.-.-	ED-EG	LS	1	1,700	1,700	300	17.6%	6
30.H.-.-	ED-EF	LS	1	10,400	10,400	1,600	15.4%	6
30.H.-.-	ED-EJ	LS	1	38,300	38,300	5,700	14.9%	6
30.H.-.-	ED-ER	LS	1	17,400	17,400	2,600	14.9%	6
30.H.-.-	ED-ES	LS	1	49,600	49,600	7,400	14.9%	6
30.H.-.-	ED-EM	LS	1	30,400	30,400	4,600	15.1%	6
30.H.-.-	ED-FD	LS	1	14,800	14,800	2,200	14.9%	6
30.H.-.-	PD-GB	LS	1	2,600	2,600	400	15.4%	6
30.H.-.-	PD-GC	LS	1	4,300	4,300	700	16.3%	6
30.H.-.-	PD-GM	LS	1	1,700	1,700	300	17.6%	6
30.H.-.-	PD-GL	LS	1	6,100	6,100	900	14.8%	6
30.H.-.-	CO-C	LS	1	1,700	1,700	300	17.6%	6
30.H.-.-	CT-HC	LS	1	18,300	18,300	2,700	14.8%	6
30.H.-.-	LCPM-JR	LS	1	5,200	5,200	800	15.4%	6
30.N.-.-	ENGINEERING DURING CONSTRUCTION							
30.N.-.-	ARCHITECT ENGINEER	LS	1	118,300	118,300	17,700	15.0%	6
30.N.-.-	ED-EG	LS	1	1,700	1,700	300	17.6%	6
30.N.-.-	ED-EF	LS	1	1,700	1,700	300	17.6%	6
30.N.-.-	ED-EJ	LS	1	13,000	13,000	2,000	15.0%	6
30.N.-.-	ED-ER	LS	1	8,700	8,700	1,300	14.9%	6
30.N.-.-	ED-ES	LS	1	23,500	23,500	3,500	14.9%	6
30.N.-.-	ED-EM	LS	1	13,000	13,000	2,000	15.0%	6
30.N.-.-	ED-FD	LS	1	4,300	4,300	700	16.3%	6
30.N.-.-	PD-GL	LS	1	2,600	2,600	400	15.4%	6
30.N.-.-	CT-HC	LS	1	18,300	18,300	2,700	14.7%	6

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
30.N.-.-	LCPM-JR	LS	1	1,700	1,700	300	17.6%	6
	Total Estimated Cost				1,607,000			
	Contingencies			7.84%		126,000		
	Total Estimated Cost and Contingencies					1,733,000		

## NOTES

- 
1. ACCOUNT 30.B IS THE SUM OF ACCOUNTS 30.E AND 30.G.
  2. TOTALS ARE ROUNDED TO THE NEAREST \$1,000.00
  3. FEDERAL, NONFEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
=====								
31.-.-.-	CONSTRUCTION MANAGEMENT							
31.-.-.-	CONSTRUCTION MANAGEMENT	LS	1	375,000	375,000	0	0.0%	7
	Total Estimated Cost				375,000			
	Contingencies			0.00%		0		
	Total Estimated Cost and Contingencies					375,000		

## REASONS FOR CONTINGENCIES

- 
1. QUANTITY VARIATIONS
  2. UNIT PRICE UNKNOWNNS
  3. UNKNOWN SITE CONDITIONS
  4. LEGAL COST
  5. NONE REQUIRED ON FUNDS TO DATE
  6. UNKNOWN MANHOURS
  7. CONTINGENCY INCLUDED IN AMOUNT

REPORTS CONTROL SYMBOL:

**\*\*\*\*\***